NATO INTERNATIONAL STAFF - DEFENCE SUPPORT DIVISION

TRIAL SERIES 03

PERFORMANCE

AVTP	TEST TITLE
03 - 10	Fuel and Oil Consumption
03 - 20	Engine and Transmission Cooling
03 - 30	Steering and Manoeuvrability
03 - 40	Braking
03 - 50	Speed and Acceleration
03 - 60	Drawbar Pull and Towing Resistance on Hard Surface
03 - 70	Power Losses
03 - 80	Standard Obstacles
03 - 90	Gradients and Slopes
03 - 100	Soft Soil Mobility
03 - 110	Fording
03 - 120	Amphibious Capability
03 - 130	Engine Cold Start
03 - 140	Lateral Guidance Force
03 - 150	Noise Emission
03 - 160 W	Dynamic Stability
03 - 170	Suspension Performance
03 - 180	Engine Idling

ALLIED
VEHICLE TESTING
PUBLICATION

AVTP : 03-10
EDITION NO.: FINAL
DATE : SEP. 1991

NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : PERFORMANCE

TEST TITLE : FUEL AND OIL CONSUMPTION

REFERENCE : STANAG 4357
STANAG 4358

EQUIVALENT : WEU 4FT6 NO.: TM 03-10
ITOP NO.: 2-2-603 (1)

FOR COMPLIANCE WITH : -

ABSTRACT : This AVTP describes how to determine the fuel consumption and range of vehicles for the accomplishment of varies types of mission, as well as the consumption of oil.

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NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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FOR THE MILITARY AGENCY OF STANDARDIZATION

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Trial Series: PERFORMANCE

Test Title : FUEL AN OIL CONSUMPTION

Paragraph

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1. SCOPE

This AVTP describes the methods to be followed to determine the fuel and oil consumption of a vehicle under controlled operating conditions. The results of these trials make it possible to compare vehicles of the same type and calculate their range under tactical conditions.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

a. Consumption at constant speeds

- Test course
  . sufficient length
  . hard surface
  . gradient ≤ 1 %
  . side slope ≤ 2 %

b. Consumption over various courses

- See AVTP 11-10 which describes endurance courses.

2.2 Instrumentation

DEVICES FOR MEASUREMENT OF:	PERMISSIBLE ERROR OF MEASUREMENT*
a. Fuel volume	2 %
b. Volume of lubricants	5 %
c Vehicle speed	1 %
d. Engine speed	2 %
e. Distance covered	2 %
f. Time	1 %
g. Fuel temperature at the tank or source of supply	1 °C
h. Tyre or track pad wear	0.5 mm
i. Tyre pressure	10 kPa
j. Vehicle weight	1 %

k. Weather data :

1) atmospheric pressure	1 %
2) ambient temperature	1 °C
3) humidity	3 %
4) wind speed	5 %
5) wind direction	50 mrad

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement of 20.

3. REQUIRED TEST CONDITIONS

3.1 Test vehicle

Ensure that:

a. The vehicle is prepared and equipped to the standard anticipated for operations or as specified by the test plan.

b. The vehicle is loaded to the condition laid down in the trials programme.

c. The vehicle has been serviced to function in accordance with the manufacturer's instructions.

d. Reference fuels and lubricants as specified by relevant NATO authority (after ratification) have been used. Until NATO agreement is ratified, developer specified POL will be used.

e. Windows and air vents are closed, and that tarpaulins have been lashed down.

f. Normal working temperatures for all components have been reached.

3.2 Test course

- The test course must be clean and dry.

3.3 Environment

- wind speed : $\leq$ 5 m/s
- desirable ambient temperature : 5 °C $\leq \theta \leq$ 25 °C
- desirable atmospheric pressure: 96 kPa $\leq$ Pa $\leq$ 102 kPa
- humidity : $\leq$ 95 %

4. TEST PROCEDURE

4.1 Fuel consumption at constant speed

a. Drive the vehicle at the speed and in the gear ratio laid down in the trials programme.

b. At stabilised speed, measure fuel consumption versus distance or time. Speed should not vary more than 2 km/h.

c. Carry out two tests in each course direction.

d. Measure fuel temperature (if required)

4.2 General operating consumption

Fuel and lubricating oil consumption is calculated from the vehicle log book. It can be measured during endurance trials (see AVTP 11-10).

4.3 No load fuel consumption (optional)

a. Vehicle stationary, transmission in neutral.

b. Bring engine speed to the rpm laid down in the trials programme, stabilise engine speed, measure fuel consumption rate.

c. Measure fuel temperature (if required)

d. Continue measurements for a length of time which will ensure the necessary accuracy. Whilst taking measurements, the engine speed must not vary more than 2 % of the reference value.

e. Repeat the test for all values laid down in the trials programme or a sufficient number of points to draw a consumption curve.

4.4 Full load fuel consumption (optional)

a. Measure fuel consumption during a drawbar pull test at full load and at different vehicle speeds as defined in the trials programme.

b. Measure fuel temperature (if required)

4.5 Controlled load fuel consumption (optional)

a. Measure fuel consumption by using a rolling rod test stand, versus speed rate and load as specified by the test plan.

b. Measure fuel temperature (if required)

4.6 Usable fuel capacity

a. Run the engine with the vehicle stationary to consume fuel until the engine stops (on level ground).

b. Fill up the tank and measure the amount of fuel required to reach the maximum level (on level ground).

c. Measure fuel temperature (if required)

5. DATA REQUIRED

5.1 For all trials

a. Vehicle configuration:
. mileage
. vehicle weight and distribution

b. Meteorological conditions:
   . ambient temperature
   . atmospheric pressure
   . humidity
   . wind speed
   . wind direction.

c. Control values laid down in trials programme.

d. Type and characteristics of fuels and lubricants.

5.2 Fuel consumption at constant speed

a. Fuel consumption and description of measurement method.

b. Engine speed.

c. Gear range.

d. Fuel temperature (if required).

e. Vehicle speed.

5.3 Consumption under general operating conditions

Quantities of fuel and lubricants taken from vehicle log book together with mileages.

5.4 No load fuel consumption

a. Fuel consumption and description of measurement method.

b. Engine speed.

c. Fuel temperature (if required).

5.5 Full load consumption

a. Note drawbar pull parameters (see AVTP 03-60).

b. Fuel consumption and description of measurement method.

c. Fuel temperature (if required).

AVTP : 03-10
EDITION NO.: FINAL
DATE : JAN. 1994

5.6 Controlled load fuel consumption

a. Rolling roller parameters (speed, torque).

b. Fuel consumption and description of measurement method.

c. Fuel temperature (if required).

5.7 Usable fuel capacity

a. Total fill-up volume until the maximum level.

b. Ambient temperature.

6. PRESENTATION OF DATA

Present the required data in narrative, tabular, graphical, pictorial or other format as appropriate.

Include:

6.1 Consumption at stabilised speed

Graph of fuel consumption rate (l/100 km) versus speed for each of the gear ratios laid down in the trials programme.

6.2 Consumption under general operating conditions

Average fuel and oil consumption rate under general operating conditions for all uses or for those laid down in the trials programme.

6.3 No load fuel consumption

Graph of fuel consumption rate versus engine speed.

6.4 Full load fuel consumption

Graph of fuel consumption rate versus load for each speed.

6.5 Controlled load fuel consumption

Table of fuel consumption for each speed.

6.6 Usable fuel capacity

Usable volume.

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PUBLICATION

AVTP : 03-20
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NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : PERFORMANCE

TEST TITLE : ENGINE AND TRANSMISSION COOLING

REFERENCE : STANAG 4357
STANAG 4358

EQUIVALENT : WEU 4FT6 NO.: TM 03-20
ITOP NO.: 2-2-607 (1)

FOR COMPLIANCE WITH : -

ABSTRACT : This AVTP describes how to determine the capability of vehicles to operate correctly in extremely high ambient temperatures.

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NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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Trial Series: PERFORMANCE

Test Title : ENGINE AND TRANSMISSION COOLING

Paragraph

AVTP : 03-20
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DATE : SEP. 1991

1. SCOPE

This AVTP describes procedures for testing the capability of the engine and transmission cooling systems to maintain temperatures within the permissible range in extremely high ambient temperatures.

This evaluation is carried out by either of the following trials:

- a climatic chamber trial
- a field trial.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

2.1.1 Climatic chamber test

a. This should allow an ambient temperature to be maintained up to the limits laid down in the trials programme.

b. It must be fitted with a fan to provide a wind corresponding to the simulated speed of the vehicle.

c. It should have a dynamometer. (If a roller dynamometer is used, it is desirable that the diameter of the roller be $\geq$ 1.5 m).

2.1.2 Field test

a. Track with hard surface (gradient $\leq$ 1 %, side slope $\leq$ 2 %).

b. Dynamometer vehicle.

2.2 Instrumentation

DEVICES FOR MEASUREMENT OF:	PERMISSIBLE ERROR OF MEASUREMENT*
a. Temperature	1°C
b. Engine speed	2 %
c. Torque of the wheels or sprockets (if required) (chamber test only)	2 %
d. Speed of wheels or sprockets (chamber test only)	2 %
e. Tractive force (on hard surface only)	2 %
f. Vehicle speed (on hard surface only)	1 %
g. Meteorological data:	
- atmospheric pressure	1 %
- ambient temperature	1°C
- humidity	3 %
- wind speed	5 %
- wind direction	50 mrad

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement out of 20.

3. REQUIRED TEST CONDITIONS

3.1 Test vehicle

Ensure that:

a. The vehicle has been prepared and equipped in accordance with standard use and with the specifications laid down in the trials programme.

b. The vehicle is in the load condition laid down in the trials programme.

c. The maintenance has been carried out as per the manufacturer's recommendations.

d. Reference fuels and lubricants as specified by relevant NATO authority (after ratification) have been used. Until NATO agreement is ratified, developer specified POL will be used.

e. Windows and air vents are properly closed and tarpaulins well lashed down.

3.2 Climatic chamber test

a. The ambient temperature will be kept to within ± 2 °C of the required value.

b. The wind speed will be kept to within ± 2 m/s of the simulated road speed.

c. Climatic conditions will be within the limits laid down in the trials programme.

3.3 Field test

a. The track must be clean and dry.

b. Climatic conditions will be within the limits laid down in the trials programme.

c. Wind speed ≤ 5 m/s.

3.4 If these climatic conditions cannot be met, it is possible to make an extrapolation (See para 4.2 d).

4. TEST PROCEDURE

4.1 Climatic chamber test

For each combination of ratios (gear box, transfer box) and required ambient temperatures, laid down in the trials programme:

a. Operate test vehicle at full throttle position and apply torque to the wheels to obtain the engine speed(s) laid down in the trials programme.

b. Operate the vehicle for a period of time sufficient to stabilise temperatures or to reach the temperature limit of one of the monitored components.

c. For every specified engine speed, the artificially created wind should be used to simulate the corresponding road speed of the vehicle, if required.

4.2 Field test

For each combination of ratios (gear box, transfer box) laid down in the trials programme:

a. Operate the test vehicle at the full throttle position, while pulling the dynamometer vehicle.

b. Using the dynamometer apply a tractive force to the test vehicle to obtain the engine speed(s) laid down in the trials programme as constant as possible.

c. Continue the test until all the temperatures are stabilised or until the temperature limit is reached for one of the monitored components which ever occurs first.

d. Should extrapolation of test results be required the cooling system should be set to operate at minimum cooling performance (i.e. the thermostat blocked open).

5. DATA REQUIRED

a. Vehicle configuration:
- mileage
- weight distribution.

b. Meteorological conditions:
- ambient temperature
- wind speed
- wind direction
- humidity
- atmospheric pressure.

c. Transmission (type and ratios).

d. Temperatures of the monitored components.

e. Torques of driving shafts (chamber test only).

f. Speed of the wheels or sprockets (chamber test only).

g. Tractive force applied during the test (field test only).

h. Vehicle speed.

6. PRESENTATION OF DATA

Present the required data in narrative, tabular, graphical, pictorial or other format as appropriate.

For each transmission ratio and each engine speed, include:

a. Temperature variations of each component observed as a function of time.

b. Variations in the tractive force or torque as a function of time.

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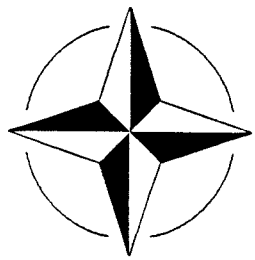

NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : PERFORMANCE

TEST TITLE : STEERING AND MANOEUVRABILITY

REFERENCE : STANAG 4357
STANAG 4358

EQUIVALENT : WEU 4FT6 NO.: TM 03-30
ITOP 2-2-609 (1)

FOR COMPLIANCE WITH : -

ABSTRACT : This AVTP describes how to determine the manoeuvrability and steering capabilities of wheeled and tracked vehicles.

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NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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Test Title : STEERING AND MANOEUVRABILITY

Paragraph

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1. SCOPE

This AVTP describes the trials to determine the manoeuvrability and road capabilities of a vehicle or vehicle train, using the following tests:

- Turning Circle
- "T"-Junction
- Swept Paths
- Steering Effort
- "Engine-Off" Steering
- Pivot Turns
- Manoeuvrability

The decision as to which of the above tests are to be carried out should be made according to the characteristics of the particular vehicle under test.
All tests are normally carried out (where applicable) in the forward direction. In certain situations it may also be considered necessary to carry them out in reverse; this requirement should be made clear in the individual test plan and recorded in the results.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

a. Test Course:

- flat surface, having slopes in travel direction of ≤ 1 % and side slopes of ≤ 2 %.
- sufficient length and area to allow the necessary measurement to be taken, and to allow the speeds defined in the test plan to be accommodated in safety.
- hard and level surface with good grip.
- desirable features:
  marking on the ground of current reference diameters and lines of angle for "swept path" and "steering effort"

b. Means of marking trajectories on the ground.

c. Cones or other means of temporarily marking lanes.

2.2 Instrumentation

DEVICES FOR MEASUREMENT OF:	PERMISSIBLE ERROR OF MEASUREMENT*
a. Diameter	1 %
b. Distance	1 %

c. Steering Angle	20 mrad
d. Effort on steering control (torque (Nm) or force (N))	2 %
e. Time	1 %
f. Vehicle Speed	1 %
g. Tyre Pressure	10 kPa
h. Tyre Wear	0.5 mm
i. Ambient Temperature	1 °C

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement in 20.

3. REQUIRED TEST CONDITIONS

3.1 Test Vehicle

Ensure that:

a. The vehicle has been prepared and equipped in accordance with standard use and within the specifications laid down in the test plan.

b. The vehicle is in the load condition specified in the test plan.

c. Maintenance has been carried out so that adjustments of the steering components are in conformity with the manufacturer's instructions. In particular, the state of the tyres or track pads should be checked (pressure and wear), brakes verified to be free from binding when not applied, and track tension (where applicable) correctly adjusted.

d. Vehicle working parts have reached their nominal working temperature, in particular power steering equipment where installed.

e. In the applicable tests below, the effect of different gun/turret orientations should be borne in mind.

3.2 Test Course

- clean and dry

AVTP : 03-30
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DATE : SEP. 1991

4. TEST PROCEDURE

4.1 Turning Circles (see diagram at Annex A)

a. Drive the vehicle in a circle with the steering wheel at maximum deflection.

b. Determine the point of measurement:

- for kerb-to-kerb measurement:
  the innermost or outermost salient part of the tyre, depending on whether an outer or inner turning circle is being measured.

- for wall-to-wall measurement:
  the innermost or outermost part of the vehicle, depending on whether an outer or inner turning circle is being measured.

c. Drive the vehicle at its lowest speed ($V \leq 5$ km/h) and mark points on the ground vertically below the inner and outermost parts of the vehicle (as detailed above) so as to produce circles.

d. Measure the diameters of the circles.

e. Repeat the above test, but this time steering in the opposition direction.

f. Repeat each test twice (to ensure repeatability).

4.2 T-Junction (see diagram at Annex B-1)

This part of the Test Procedure determines the minimum road width of a "T"-Junction that a vehicle or combination can successfully negotiate. The test plan should identify whether the wall-to-wall clearance or the kerb-to-kerb clearance is required. To obtain a repeatable result, it is recommended that the result is determined by calculation (see paragraph 4.2.1) and then verified by a practical demonstration (see paragraph 4.2.1d) rather than by the practical measurement described in paragraph 4.2.2.

4.2.1 Calculation Method

a. The appropriate inner and outer circle diameters, for right-hand lock, are obtained from the procedure at paragraph 4.1. These may be the wall-to-wall diameters, or the kerb-to-kerb diameters, as appropriate.

b. The minimum road width for right-hand lock is calculated as shown in the diagram at Annex B-2.

c. A similar calculation is performed for the left-hand lock.

d. The result to be presented is the larger of that for the right-hand lock and that for the left-hand lock. If required, the result can be confirmed by setting up a simple "T"-Junction on the ground, of the minimum dimension calculated above, and attempting to negotiate it without shunting.

4.2.2 Practical Measurement (see Annex B-3)

a. Mark out a right-angled datum corner (ABC) on the ground.

b. With the vehicle positioned at "A" and facing parallel to the line "AB", the vehicle is to be driven forward slowly ($V \leq 5$ km/h) to end up facing parallel to line "BC", at position "C".

c. The accuracy of the result depends on a close agreement between measurements "X" and "Y", if necessary repeat 4.2.2b until "X" and "Y" approximately agree.

d. Whichever of measurements "X" and "Y" is the larger, is to be given as the minimum road width for a right-hand turn.

e. Carry out a similar procedure for a left-hand turn.

f. The overall result of the test is the greater of the measurements for right-hand turn and for left-hand turn.

4.3 Swept Paths (see diagrams at Annex C)

a. Follow the trajectory laid down in the test plan (determined by the turning radius and the angle between entry and exit) at a speed of less than 5 km/h.
Unless otherwise stated in the trials programme, the test should be done for angles of 90°, 180° and 270°.

b. Throughout the tests, mark on the ground the trajectories of the innermost and outermost points of the vehicle.

c. From the centre of the turn, trace radial lines at angles of every 10°. For each of these angles, measure the distance from the turn centre point to the intersection of both the innermost and outermost trajectories (traced in para. 4.3b) with the appropriate radial line.

d. Repeat the test for all the circle diameters and angles of turn laid down in the test plan for each direction of turn.

4.4 Steering Effort

4.4.1 Vehicle Stationary, Engine Running

a. Slowly and steadily turn the steering wheel from neutral to maximum right-hand lock and return to centre.

b. Measure effort throughout the test, the time taken to go from centre to maximum lock, and the time taken to return to the central position.

c. Repeat 4.4.1a and b for the left-hand lock.

d. For vehicles with power steering, carry out the test with and without power steering (if possible).

4.4.2 Vehicle Moving

a. Determine the steering wheel angle necessary for the vehicle to traverse a circle having the radius specified in the test plan (this radius should normally be 30 metres).

b. Stabilise the vehicle on a straight line tangential to the required circle at the specified road speed. (Unless otherwise specified in the test plan, the speed for vehicles under 10 Tonne Gross Weight is 32 km/h, and the speed for vehicles over 10 Tonnes Gross Weight is 16 km/h).

c. Turn the steering wheel as quickly as possible to the angle laid down in paragraph 4.4.2a, follow the circle for 180 degrees, exit along the tangential line and measure:

- the steering effort during the complete manoeuvre.
- the time taken to go from neutral position to the angle specified in paragraph 4.4.2a.
- the time taken to come back to the neutral position.

d. Repeat the test twice in each direction of turn.

e. Repeat the test for each alternative road speed and circle diameter laid down in the test plan.

f. For vehicles with power steering, carry out the test with and without the power steering (if possible).

4.5 "Engine-Off" Steering (see diagram at Annex D)

a. Mark out a course, as shown at Annex D, on a smooth and level open area.

b. Drive the test vehicle, at 10 km/h, to enter the course at "A". Shut off the engine, and disengage the transmission 10 metres before the Steer Point, and attempt to drive the vehicle through the course to exit at "C".

c. Repeat 4.5b but this time entering the course at "B".

d. If the vehicle satisfactorily completes the above procedures, repeat 4.5b and 4.5c with the entry speed progressively increased in stages, until a speed is reached at which the vehicle fails to pass through the course without crossing the course boundary.
SAFETY NOTE: Discontinue testing if the vehicle approaches its limit of stability.

e. The maximum entry speed for point "A" and for point "B" are recorded as the results of this test.

4.6 Pivot Turns

4.6.1 The vehicle, fitted with marking devices on its extremities, is to be positioned on a hard and level surface, with the engine at idle and the transmission in neutral.

4.6.2 With the marking device activated, apply full throttle and full steer to right, simultaneously. Measure the time to complete a 360-degree circle, and measure the outer wall-to-wall envelope used by the vehicle to complete the circle.

4.6.3 Repeat the above procedure, but this time using full steer to the left.

4.6.4 Repeat the whole procedure above, but this time measure the time taken to complete a 360-degree turn at maximum rate, with the vehicle already rotating at full rate at the start of each measured revolution.

AVTP : 03-30
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4.7 Manoeuvrability

4.7.1 Constant step slalom (see diagram at Annex E)

a. Set up the course shown, with distance "d" set at 10 metres.

b. Cross the line (1-1a) at the lowest vehicle speed laid down in the test plan and drive in a straight line through the section (1-2); attempt to continue through the remainder of the course (2-5) whilst keeping the speed as steady as possible at this same value. The time needed to cross the section (3-4) is to be measured.

c. Repeat (b) at the various speed increments laid down in test plan until:

- the maximum speed laid down in the test plan is reached or,

- it becomes impossible to cross the test area without knocking the cones down, or

- a speed is reached at which there is a risk of the vehicle falling onto its side,

whichever occurs first.

d. Repeat the above procedure ((a) to (c)), but with the distances "d" set in turn at 15, 20 and 30 metres.

e. Repeat the entire above procedure ((a) to (d)), but with a different driver.

4.7.2 Increasing step slalom (see Annex E)

a. Begin with the test vehicle stationary at the starting position (line 1-1a), with:

- engine idling, transmission disengaged
- brakes off.

b. Accelerate the vehicle as quickly as possible along the course (1-3), using the engine and transmission to the best effect, or using gear ratio defined in the test plan, until it becomes impossible to cross the test are without knocking down the cones, or there is a risk of the vehicle falling onto its side, whichever occurs first. Measure the time needed to cross the section (2-3) and note the vehicle behaviour.

c Repeat the above procedure ((a) to (b)) as necessary to get a valid result.

d. Repeat the entire above procedure ((a) to (c)) with a different driver.

4.7.3 Decreasing step slalom (see Annex E)

a. Cross the line (4.4a) at the lowest vehicle speed laid down in the test plan and drive in a straight line through the section (4-3). Continue to drive through the remainder of the course (3-1), decreasing the speed as necessary to avoid knocking the cones down. Measure the time needed to cross the section (3-2) and note the vehicle behaviour.

b. Repeat (a) at the successive higher speeds (if any) specified in the test plan.

c. Repeat the entire above procedure ((a) to (b)) with a different driver.

5. DATA REQUIRED

5.1 General Data

- vehicle identification: make, type, registration number.
- vehicle configuration: weight, load distribution, vehicle mileage.
- data to be checked according to the test plan (tyre wear and pressure).
- ambient temperature.

5.2 Turning Circles

- type of circles: between walls or kerbs/external or internal.
- direction of turn.
- diameters.
- vehicle speed.

5.3 "T"-Junction

- direction of turn.
- minimum width of roads.

OR

- whether or not the vehicle is capable of negotiating a junction of a width specified in the test plan.

- vehicle speed.

5.4 Swept Path

- reference turning circle diameter.
- angle between entry and exit.
- internal limit.
- external limit.
- direction of turn.
- vehicle speed.

5.5 Steering Effort

- direction of turn.
- time taken to turn.
- steering effort.
- vehicle speed.
- turning radius.

5.6 "Engine-Off" Steering

- maximum speed.
- direction of steering.

5.7 Pivot Turns

- diameters.
- times.

5.8 Manoeuvrability

- distance (slalom step)
- time
- vehicle behaviour
- gear ratio used.

6. PRESENTATION OF DATA

Present the required data in narrative, tabular, graphical, pictorial or other format as appropriate.

6.1 Turning Circles

- diameters for each direction.

6.2 "T"-Junction

- minimum width of road in both turning directions.

Or

- opinion on the ability to negotiate the junction laid down in the test plan.

- statement of method used.

6.3 Swept Path

- diameter and angle of reference turn.
- plot of swept paths laid down in the test plan.

6.4 Steering Effort

- steering effort for each turn.
- time taken to turn.
- vehicle speed.
- turning diameter.

6.5 "Engine-Off" Steering

- maximum speed for each direction.

6.6 Pivot Turns

- diameters of all circles.
- times for all turns.

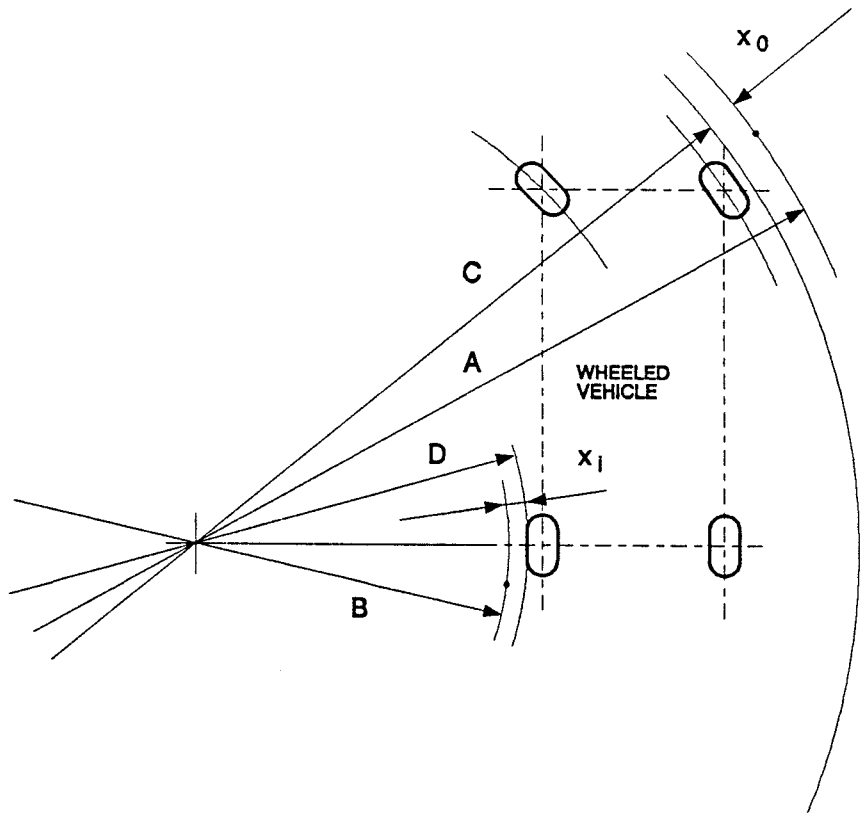
6.7 Manoeuvrability

- times, speeds, distance for all tests.
- gear ratios used (where applicable).
- comments on vehicle behaviour (steering system).

AVTP : 03-30
EDITION NO.: FINAL
DATE : SEP. 1991

ANNEX A

Turning Circle Diameters for Wheeled Vehicles



• VEHICLE PROJECTIONS

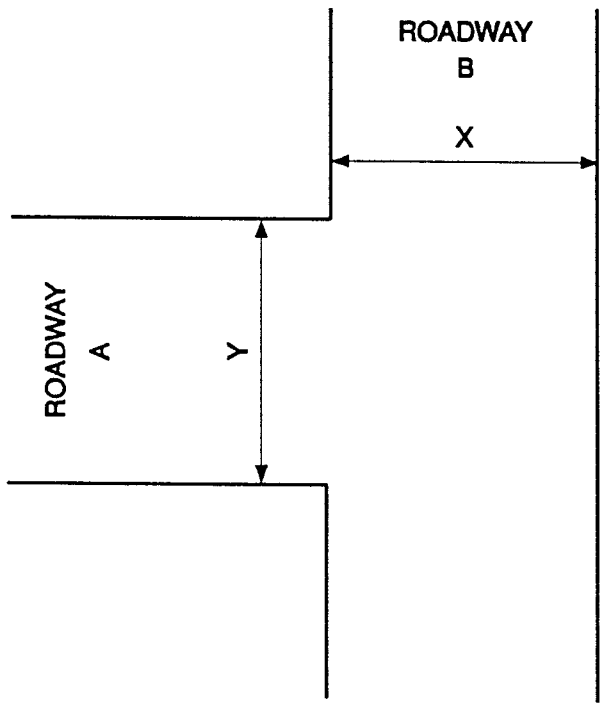
TURNING CIRCLE DIAMETERS:

A	–	OUTER FOUL POINT	/	WALL – TO – WALL (DRIP TRACK MEASUREMENT)
B	–	INNER FOUL POINT	/	WALL – TO – WALL (DRIP TRACK MEASUREMENT)
C	–	OUTER		KERB – TO – KERB (CALCULATED: $C = A - 2 \cdot x_0$)
D	–	INNER		KERB – TO – KERB (CALCULATED: $D = B + 2 \cdot x_I$)

AVTP : 03-30
EDITION NO.: FINAL
DATE : SEP. 1991

ANNEX B

Minimum Width for "T"-Junction Hazard



NOTES:

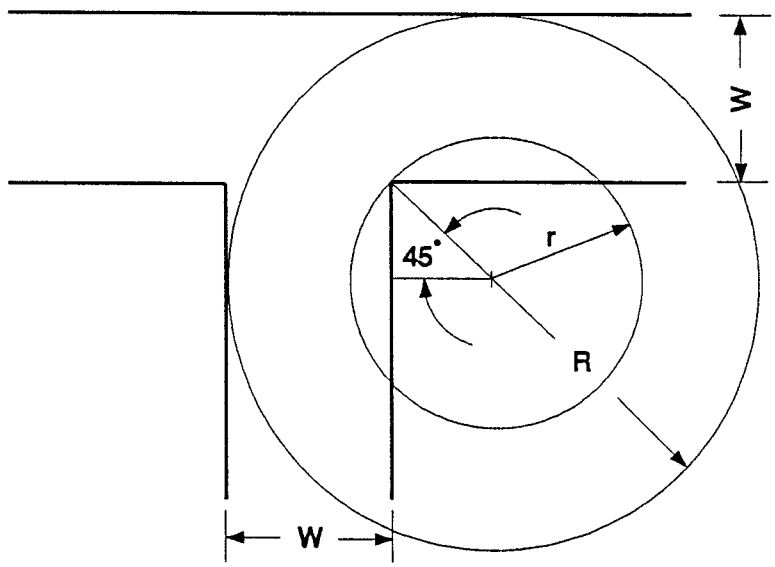
1 "X" and "Y" are to be equal.

2 The Test result is the minimum value of "X" (and "Y") which allows the vehicle to negotiate the T-junction in all directions without fouling.

AVTP : 03-30
EDITION NO.: FINAL
DATE : SEP. 1991

ANNEX B

Calculation of Minimum Road Width



R = 1/2 · OUTER TURNING CIRCLE DIAMETER

r = 1/2 · INNER TURNING CIRCLE DIAMETER

$W = R - r \cdot \sin 45^{o}$

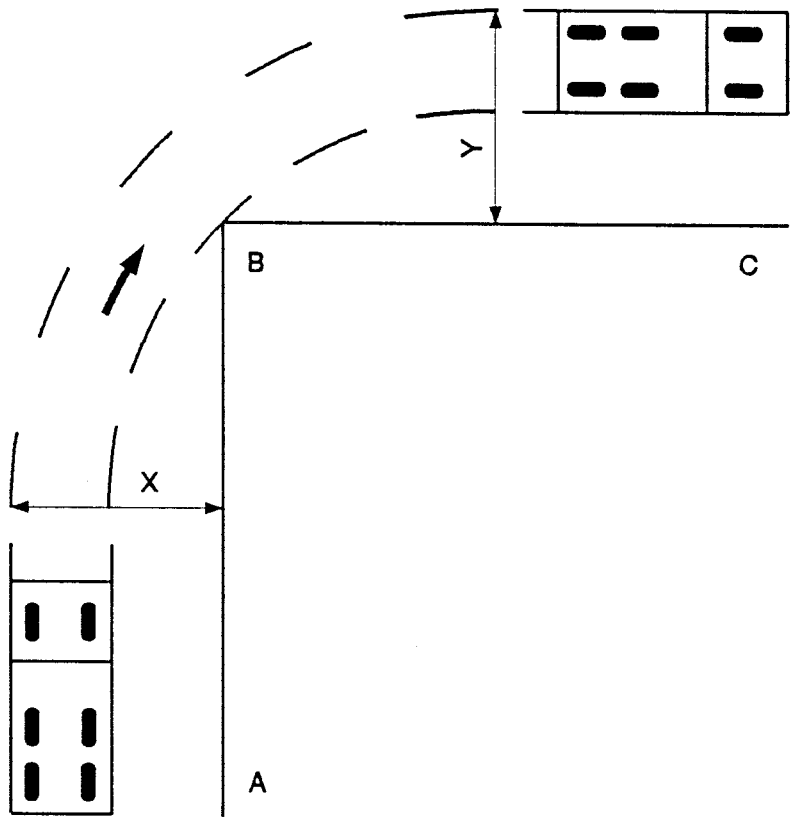
WHERE W = MINIMUM ROAD WIDTH OF "T"-JUNCTION

The calculation must also be performed using the values of r and R for a turning circle on the opposite lock. The higher value of "W" must be presented as the result.

AVTP : 03-30
EDITION NO.: FINAL
DATE : SEP. 1991

ANNEX B

Practical Measurement of Minimum Road Width



NOTES:

1 Dimension "X" is the greatest perpendicular distance from line AB to the outer drip track.

2 Dimension "Y" is the greatest perpendicular distance form line BC to the outer drip track.

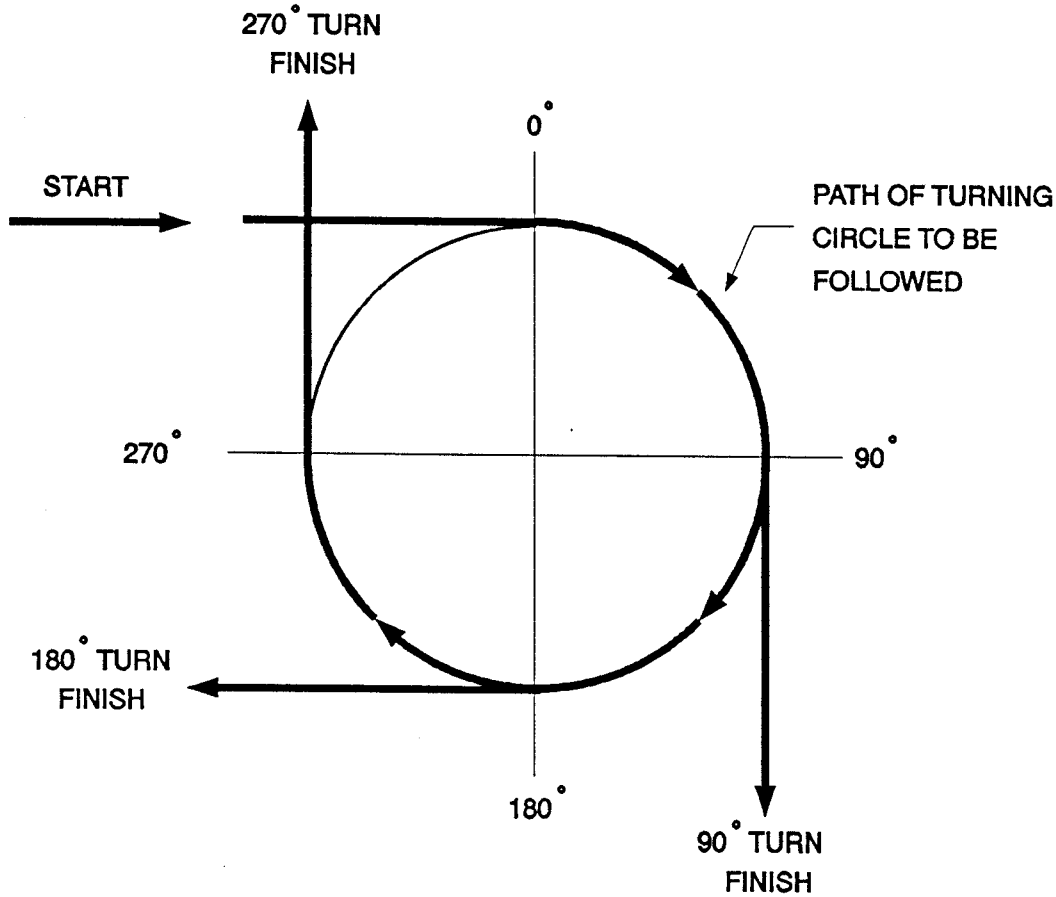
3 The exercise must be repeated (if necessary) until "X" and "Y" approximately agree.

4 The result for a right-hand turn is the greater of "X" and "Y".

AVTP : 03-30
EDITION NO.: FINAL
DATE : SEP. 1991

ANNEX C

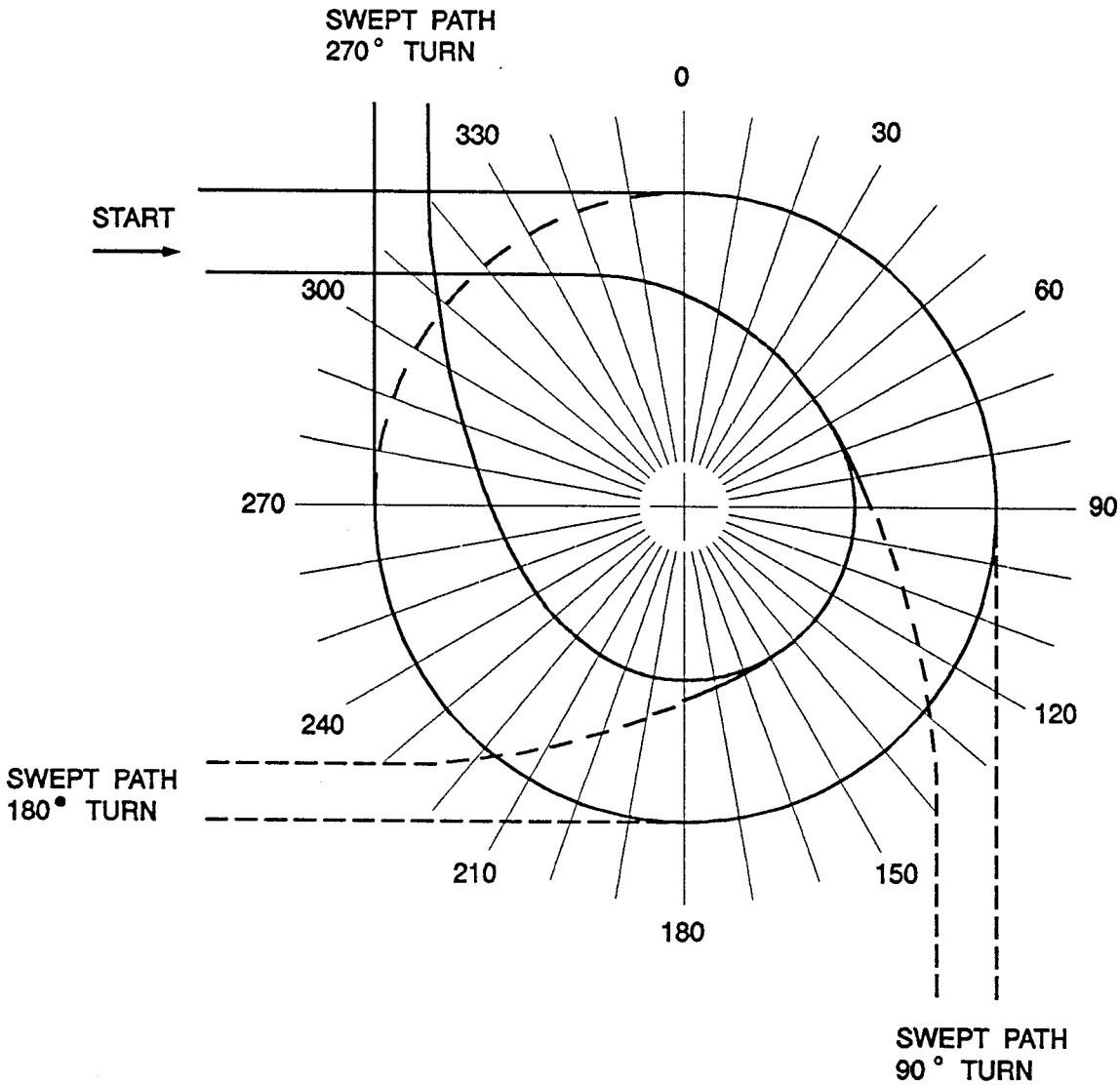
Vehicle Swept Path Start and Finish Points



AVTP : 03-30
EDITION NO.: FINAL
DATE : SEP. 1991

ANNEX C

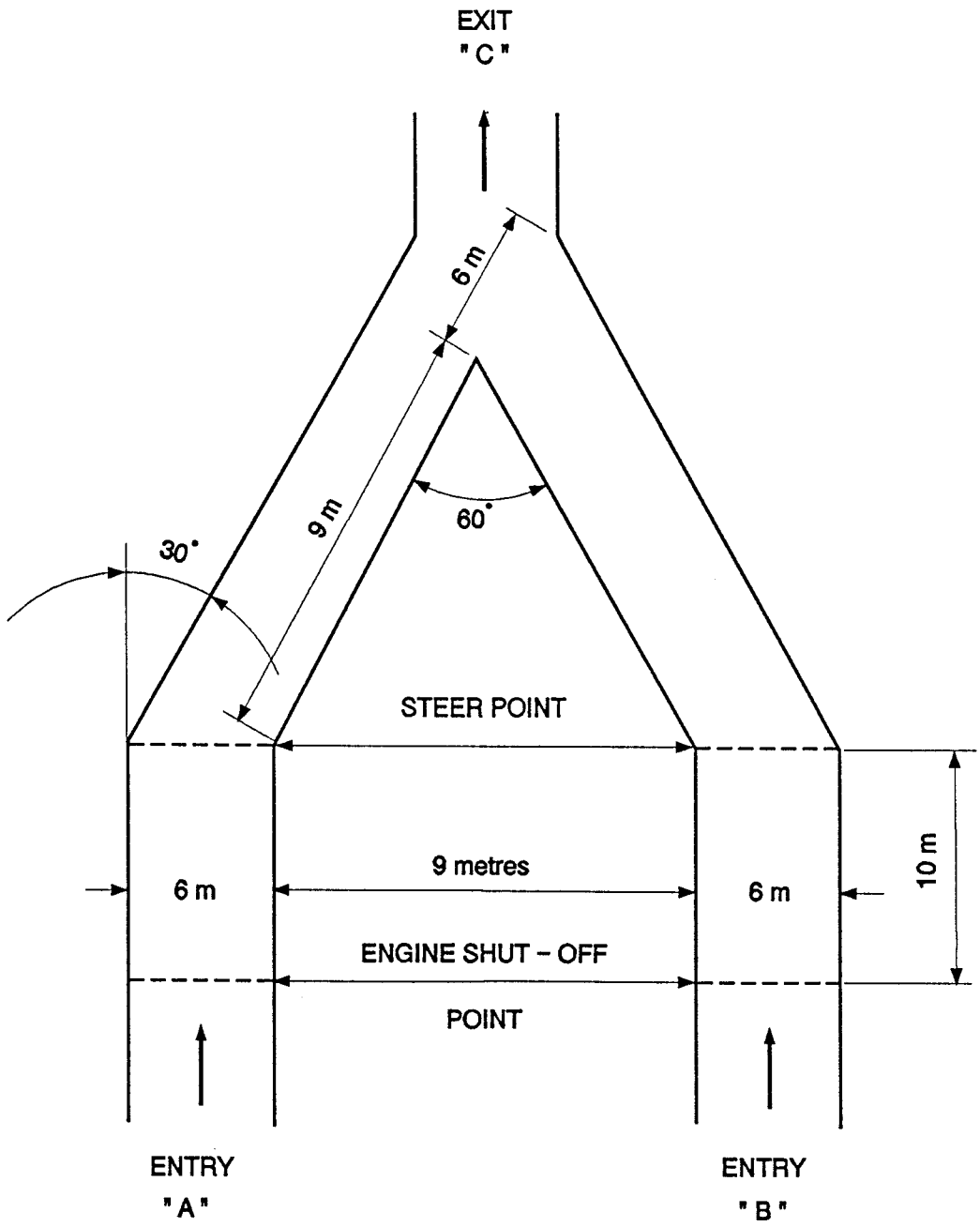
Typical Swept Path of Vehicle Train for Turns of 90°, 180° and 270° at Constant Turning Circle Diameters



AVTP : 03-30
EDITION NO.: FINAL
DATE : SEP. 1991

ANNEX D

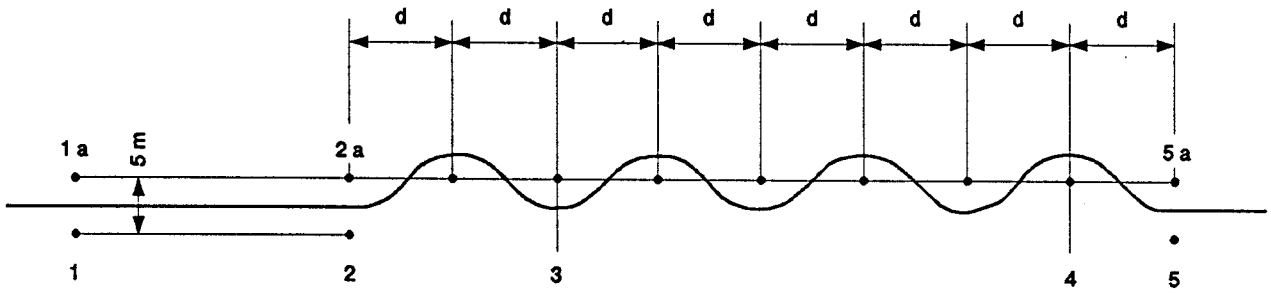
"Engine-Off" Steering Course



AVTP : 03-30
EDITION NO.: FINAL
DATE : SEP. 1991

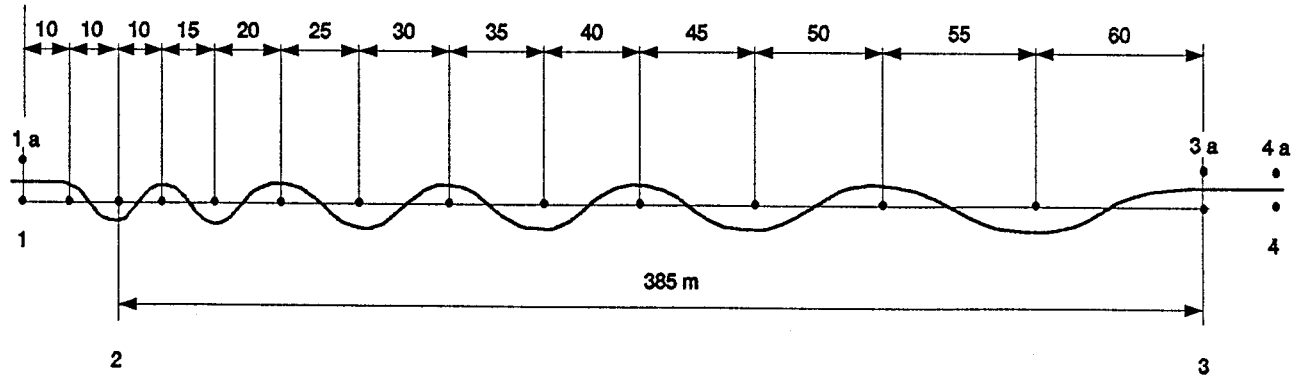
ANNEX E

Constant step slalom



Slalom No 1 d = 10 m
Slalom No 2 d = 15 m
Slalom No 3 d = 20 m
Slalom No 4 d = 30 m

Increasing and decreasing step slalom



ALLIED
VEHICLE TESTING
PUBLICATION

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EDITION NO.: FINAL
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NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : PERFORMANCE

TEST TITLE : BRAKING

REFERENCE : STANAG 4357
STANAG 4358
ISO STANDARD 6597/80

EQUIVALENT : WEU 4FT6 NO.: TM 03-40
ITOP NO.: 2-2-627

FOR COMPLIANCE WITH : -

ABSTRACT : This AVTP describes the procedures for evaluating the braking performance of wheeled and tracked vehicles (with brakes in cold and hot conditions) including Antilock Braking System (ABS).

AVTP : 03-40
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NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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FOR THE MILITARY AGENCY OF STANDARDIZATION

(Signature)

AVTP : 03-40
EDITION NO.: FINAL
DATE : SEP. 1991

RECORD OF CHANGES, AMENDMENTS AND RESERVATIONS *)

Identification of Change or Amendment and Reg.No.(if any) and date	Date Entered	NATO Effective Date	By whom entered Signature, Rank, Grade or Rate, Name of Command

*) See Reservations Overleaf

AVTP : 03-40
EDITION NO.: FINAL
DATE : SEP. 1991

Trial Series: PERFORMANCE

Test Title : BRAKING

Paragraph

AVTP : 03-40
EDITION NO.: FINAL
DATE : SEP. 1991

1. SCOPE

This document describes procedures for evaluating the braking performance of wheeled and tracked vehicles in static or dynamic conditions.
The performance of service, parking or emergency brakes is one of the principal considerations for vehicle safety evaluation and is also a major source of information about the braking system's ability to absorb energy.
Where traffic regulations are more stringent than specified below the provision of the traffic regulations shall apply.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

a. Straight, level course with high grip ($K \geq 0.75$, gradient ≤ 1 %, side slope ≤ 2 %).

b. High grip course of sufficient length to allow braking in hot brake conditions (repeat braking).

c. High grip constant gradient course of sufficient length to simulate a long descent, or dynamometer vehicle to simulate a long descent where only a level course is available.

d. Hard surface test slopes with high grip (≥ 0.75) for parking brake tests.

e. Straight level course with high and low grip areas ($K_1 \geq 0.5$ and $K_2 \leq 0.3$ with $K_1/K_2 \geq 2$).

The test course should be configured to provide:
- lengthwise transition from high to low grip
- lengthwise transition from low to high grip
- a low grip area on one side of the road centreline, and a high grip area on the opposite side of the road centreline.

f. Video (desirable).

g. Means of detection of wheel locking.

2.2 Instrumentation

DEVICES FOR MEASUREMENT OF:	PERMISSIBLE ERROR OF MEASUREMENT*
a. Speed	1 %
b. Time	1 %
c. Distance (including stopping distance)**	1 %
d. Deceleration (if necessary)	2 %
e. Force (on braking control and traction)	2 %
f. Brake temperature	5°C
g. Meteorological data:	
- atmospheric pressure	1 %
- ambient temperature	1°C
- humidity	3 %
- wind speed	5 %
- wind direction	50 mrad
h. Brake circuit pressure	5 %
i. Tyre pressure	10 kPa
j. Tyre or track pad wear	1 mm
k. Vehicle yaw angle	2°

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement in 20.

** Stopping distance is defined as the distance travelled from activating the braking control until the vehicle stops.

3. REQUIRED TEST CONDITIONS

3.1 Test vehicle

Ensure that :

a. The vehicle has been prepared according to the equipment and load specifications laid down in the trials programme.

b. The vehicle is loaded according to the load configuration specified in the trials programme.

c. Maintenance is carried out to ensure that the vehicle functions according to the manufacturer's specifications. Particular attention should be given to the following aspects of the brake system:

- components susceptible to wear (brake pads), whether new or run in

- brake play adjustment

- brake regulation systems adjustment

d. All windows and air vents are properly closed, and tarpaulins are well lashed down.

e. Particular care should be paid to the general condition, wear and pressure of the tyres as well as their distribution around the vehicle. Track pads should be similarly checked.

3.2 Test course

The course must be clean and dry in the high grip areas.

3.3 Environment

It is desirable to conduct testing under the following environmental conditions:

a. Wind speed:	≤ 5 m/s when in gusts ≤ 3 m/s average value
b. Desired ambient temperature:	$0° \leq \theta < 30$ °C
c. Humidity:	≤ 95 %

4. TEST PROCEDURE

4.1 Braking with service brakes in cold condition

4.1.1 General

- The brakes are considered to be in the cold condition if the surface temperature measured by contact on outside of the brake drums or on the brake discs is below 100 °C before brake application. For oil-embedded brakes, the normal operating oil temperature specified by the manufacturer is considered "cold".

- See AVTP 03-110 concerning braking test after fording.

4.1.2 Tests with transmission disengaged

a. Measure the temperature of the brakes before each test.

b. Stabilise vehicle speed at the value specified in the test programme within 1 km/h.

c. Apply brakes (as quickly as possible) to the vehicle by simultaneously activating the main brake and disengaging the transmission or putting automatic gear boxes into neutral, wherever possible, to bring the vehicle to rest.

d. Measure the stopping distances and record deceleration, circuit pressure (if required) and braking control force versus time.

e. Note the time elapsed between the beginning of braking control action and the time when 90 % of average deceleration is reached in stabilised conditions.

f. Repeat the test for a minimum of five different pedal force values increasing them without exceeding the limit set by regulations or the trials programme.

g. The test is to be carried out with the vehicle being first unladen and then laden.

h. During the test with the laden vehicle, a measurement must be taken with an efficiency at least equal to the prescribed efficiency, to verify there is no wheel or track locking or abnormal vehicle behaviour (deviation from vehicle's trajectory or abnormal vibrations); the control force required to achieve this efficiency will be used as "reference value" for the remaining tests.

i. For each trial configuration, a minimum of two tests will be carried out.

4.1.3 Tests with transmission engaged

a. Complementary tests are carried out at several reference speeds; except if specified otherwise these will be successively equal to 30, 55 and 80 % of the maximum vehicle speed.

b. Measure the temperature of the brakes before each test.

c. Stabilise vehicle speed at the value indicated in the trials programme within 1 km/h.

d. Brake using the main brake control (as quickly as possible), apply a force lower than the prescribed limit; disengage transmission just before coming to rest to avoid engine stall.

e. Measure stopping distance and record deceleration, circuit pressure (if required), control force versus time; note any abnormal behaviour (wheel or track locking, abnormal vibrations, etc.).

f. Note the time elapsed between the beginning of braking control action and the time when 90 % of average deceleration is reached in stabilised conditions.

g. Carry out the tests with an unladen vehicle (immediately after tests with an unladen vehicle with transmission disengaged), then with a laden vehicle.

h. For each trial configuration, a minimum of two tests must be performed.

4.1.4 Tests for trailers and semi-trailers

a. These tests are to be performed on laden trailers or semi-trailers.

b. The trailer or semi-trailer must be towed at the speed specified in the trials programme, stabilised within 1 km/h.

c. The trailer brakes are the only ones to be operated by pressure or effort, in conformity with regulations or with the value specified by the trials programme and with the towing vehicle's transmission disengaged.

d. Measure average deceleration* (dm) in stabilised conditions.

e. Calculate the braking rate (z_R) using the following formula:

$$z_R = (z_{R+M} - R) \frac{P_R + P_M}{P_R} + R \quad \text{where}$$

- R is the resistance to running = 0.01
- dm is the average deceleration* of towing vehicle + trailer
- z_{R+M} is the average deceleration rate (dm/g) of towing vehicle + trailer
- P_M is the total static weight transmitted to the ground by all towing vehicle's wheels
- P_R is the total static weight transmitted to the ground by all trailer's or semi-trailer's wheels.

* Average deceleration is defined as the average of the maximum sustained deceleration rate.

4.1.5 Motor vehicles test: emergency braking (optional tests)

a. Stabilise the vehicle speed at the value specified by the trials programme within 1 km/h.

b. Operate service brakes as quickly as possible with the maximum control force authorised by the trials programme and with the transmission engaged.

c. Measure stopping distance; record deceleration, circuit pressure (if required) and control force versus time, and note vehicle's behaviour.

d. Determine the time elapsed between the beginning of brake pedal action and the moment when 90 % of average deceleration is reached in stabilised conditions.

e. Carry out the test with an unladen vehicle and then with a laden vehicle.

4.1.6 Tests for trailers equipped with inertial ("over-run")brakes

a. Carry out the test described in paragraph 4.1.2 with the towing vehicle only.

b. Carry out the test described in paragraph 4.1.2 with the towing vehicle and trailer.

c. Note the behaviour of the trailer.

4.2 Braking with service brakes in hot condition

4.2.1 Procedure for warming-up with repeated brakings and measuring the residual effectiveness (for motor vehicles only)

a. Tests must be carried out with a laden vehicle.

b. Brakes must be warmed up, using the following procedure:

- before the first warm-up braking, brakes must be cold (see paragraph 4.1.1)

- the vehicle speed at the start of the warming up period is normally V = 80 % V_{max}; however this speed may be limited to a given value specified by the trials programme

- the service brake must be operated, using a control force, that during the first application results in an average deceleration of 3 m/s^2; this same control force must be used during successive brakings (although this may produce different deceleration levels)

- brakes are released when the vehicle speed reaches V/2

- The highest gear ratio (excluding overdrive etc.) must be continuously engaged during each of these brake applications

- immediately after releasing the brake pedal, accelerate to reach, as quickly as possible, the speed V again: stabilise speed V for a minimum of 10 seconds before next braking

- start the next braking procedure t* seconds after the beginning of the previous cycle

- n* successive tests have to be performed according to the above procedure

* t and n are defined by the regulations or by the trials programme.

c. Measure the residual effectiveness of the braking with the test described under paragraph 4.1.2 b, c, and d; this must take place immediately after the warming up procedure described under paragraph 4.2.1 b, applying the pedal reference force defined under paragraph 4.1.2 h. In all cases, the test must be carried out less than 60 seconds after the last brake warm-up.

d. If the prescribed braking effectiveness for hot brakes is not reached, the test may be carried out a second time according to the specifications of paragraph 4.2.1 b, c, and d; the control force may be increased but should not exceed the prescribed limits.

e. If the test site does not make it possible to comply with all conditions stated in the procedures (i.e. cycle time, test speed), they can be modified provided that the total duration of the test and the total energy produced remain unchanged.

f. Record the brake temperature (if required).

4.2.2 Procedure for warming-up with continuous braking and measuring the residual effectiveness

a. The tests must be carried out with vehicle laden.

b. Brakes must be warmed up, using the following procedure:

- at the start of the warming-up period, brakes must be cold (see paragraph 4.1.1)

- the vehicle speed must be kept constant on a downhill slope using the service brake, the engine brake or retarder; speed, gradient and distance are laid down in the trials programme

- if no test site corresponding to the prescribed parameters (slope gradient and distance) exists, the necessary braking force can be achieved by towing the test vehicle or trailer and by measuring the tow force which

must correspond to the value calculated on the basis of the vehicle's weight and the slope gradient; this force must not deviate by more than 5 % from the calculated value.

c. Measure the axle braking residual effectiveness as defined under paragraph 4.1.2 b, c, and d, for motor vehicles and under 4.1.4 for trailers and semi-trailers.

d. If the prescribed braking effectiveness for hot brakes is not reached, the test may be carried out a second time according to the specifications of paragraph 4.2.1 b, c, and d; the pedal force may be increased but should not exceed the prescribed limits.

e. Record the brake temperature (if required).

4.3 Emergency brakes test

4.3.1 For vehicles equipped with a separate emergency (secondary) braking system

a. Carry out all tests described under paragraph 4.1.2 on the separate braking system (except 4.1.2 e).

b. Carry out the tests described under paragraph 4.1.2 on the service brake system for each type of failure of isolated circuit (except 4.1.2 e).

4.3.2 For vehicles equipped with separate circuits only

Carry out all tests described under paragraph 4.1.2 on the main brake system for each type of failure of an isolated circuit.

4.4 Parking brakes test

4.4.1 For motor vehicles only

a. Drive the loaded vehicle, facing uphill onto the test slope (the gradient of which is laid down in the trials programme).

b. Hold the vehicle using the parking brakes in compliance with the procedure prescribed by the manufacturer or, failing indications to the contrary:

- stop the vehicle using service brakes
- disengage transmission
- apply parking brakes and if necessary measure the control force
- release service brakes

c. Stop engine (except if safety is at risk).

d. Wait for five minutes while checking for any vehicle movement and note its origins (rotation of wheels or tracks, slipping, etc.).

e. Drive vehicle off the test slope and repeat the test with vehicle facing downhill.

4.4.2 For trailers and semi-trailers

a. Tow the laden trailer onto the test slope, facing uphill (the gradient of which is laid down in the trials programme).

b. Apply the trailer parking brakes.

c. Disconnect prime mover from trailer (mechanical, electrical, pneumatic and hydraulic connections) while maintaining a safety link with no force being applied.

d. Wait for fifteen minutes while checking possible trailer movements and note their cause.

e. Repeat the procedures 4.4.2 a to 4.4.2 d with trailer facing downhill.

4.4.3 For prime mover and trailer (or semi-trailer) combinations

Perform tests described under 4.4.1 a to 4.4.1 e using only the parking brakes of the prime mover; with both prime mover and trailer laden.

4.5 Antilock Braking Systems (ABS) tests

General guidance on ABS tests and the determination of parameters can be found in the Annexes to this AVTP. If the test is being used to determine compliance with EEC regulations, it will be necessary to measure the coefficient of friction of the low and high grip surfaces. If the test is being used strictly to determine the performance of ABS, then only the ratio of the grips needs to be determined.

4.5.1 Measurement of the friction coefficient of the test course

This measurement must be taken with the test vehicle, before the ABS performance tests; using the methods specified in the Annex.

4.5.2 Tests over surfaces having a single coefficient of friction

a. Carry out a test as described under paragraph 4.1.5 on a high grip course ($K \approx 0.8$), at low and high speeds, the value of which are specified by the test programme.

b. Note any wheel locking.

c. Repeat procedure 4.5.2 a and 4.5.2 b on a low grip course ($K \leq 0.3$ with $K_1/K_2 \geq 2$).

d. Carry out tests 4.5.2 a to 4.5.2 c with a laden and unladen vehicle.

4.5.3 Tests on heterogeneous surface, lengthwise

a. Carry out a test as described under 4.1.5 on a course made up of high grip (K_1) section followed by a low grip one (K_2); the test speed and the time at which braking occurs must be such that the ABS is permanently in operation over the high grip section, transition from one type of surface to the other taking place at high and then at low speed.

b. For each axle connected to the ABS, note any wheel locking when the vehicle goes from high grip to low grip section, or any fault in the vehicle's path.

c. Perform a test as described under 4.1.5 on course, first with a low grip (K_2) section followed by a high grip one (K_1); the test speed and the time at which braking occurs must be such that the ABS is permanently in operation on the low grip section, the transition from one section to the other taking place at the speed prescribed by the test programme.

d. Note, for each axle connected to the ABS, whether wheel locking occurs when the vehicle goes from the low grip section to the high grip one, or any deviation from the vehicle initial path.

e. Carry out tests a) to d) with a laden and unladen vehicle.

4.5.4 Tests on heterogeneous surfaces, crosswise (optional)

a. On a course with a low grip half (right or left side) and a high grip half (left or right side) with the vehicle facing along the test course, perform a test as described under 4.1.5.

b. Note any wheel locking or faulty path and measure the distance and the deceleration.

c. Tests 4.5.4 a and 4.5.4 b are carried out first with a laden vehicle then with an unladen one.

d. Tests 4.5.4 a to 4.5.4 c must be performed in both directions on the course.

5. DATA REQUIRED

5.1 For all tests

- identification of the vehicle
- meteorological conditions
- test course characteristics.

5.2 Service brake tests with cold brakes

- vehicle speed as a function of time
- brake control force as a function of time
- pressure of braking system circuits (desirable)
- stopping distance
- deceleration as a function of time
- temperature of brakes (drums or discs) before each test
- comments on vehicle behaviour.

5.3 Service brake tests with hot brakes

In addition to the data specified under paragraph 5.2, the following should be noted:
- definition of the warming-up cycle
- temperature of brakes at the end of the warming-up period (desirable)

5.4 Emergency brake tests

- same as 5.2.

5.5 Parking brake tests

- control force, if required
- time during which vehicle is stationary
- values of gradients used for these tests
- data on brake efficiency and comments on vehicle behaviour.

5.6 ABS systems tests

In addition to the data described under paragraph 5.2, the following should be recorded:
- total weight and weight distribution on each axle
- any wheel locking.

6. PRESENTATION OF DATA

Present the required data in narrative, tabular, graphical, pictorial or other format, as appropriate.

Include:

6.1 Service brake tests with cold brakes

- stopping distance versus control force for each initial speed
- average deceleration versus control force for each initial speed (if required)
- average deceleration versus speed (if required)
- rise time*

6.2 Service brake tests with hot brakes

- control force
- stopping distance for test of residual efficiency
- rise time*
- average deceleration (if required).

* Rise time is defined as the time from actuating the brake pedal until 90 % of average deceleration is reached.

6.3 Emergency brake tests - or failure of service brake

- stopping distance
- average deceleration (if required).

6.4 ABS tests

- coefficient of friction K_1
- coefficient of friction K_2
- stopping distance
- average deceleration.

AVTP : 03-40
EDITION NO.: FINAL
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ANNEX A

MEASUREMENT OF ADHESION UTILISATION

1. MEASUREMENT PROCEDURE FOR MOTOR VEHICLE

1.1 Determination of coefficient of friction (K)

1.1.1 The coefficient of friction (K) is defined as the quotient of the maximum braking forces on one axle without wheel locking and the corresponding dynamic load on the same axle.

1.1.2 Brakes must be applied to one test vehicle axle only, at an initial speed of 50 km/h. Braking forces must be evenly distributed between the wheels of that axle. The ABS must be disconnected.

1.1.3 Several tests, with increasing braking pressures in stages, must be carried out to determine the maximum braking rate of the vehicle (z_m). During each test, the pedal force must be kept constant and the braking rate must be determined by measuring the time taken to go from 40 km/h to 20 km/h, using the following formula:

$$z_m = \frac{0.56}{t}$$

t is time in seconds.

1.1.4 Braking forces must be calculated on the basis of the measured braking rate and the resistance to rolling of the axles to which no brake has been applied ; this resistance is assume to be to 0.015 times the static load on the axle if it is a driving one and 0.010 times the static load on the axle, if it is not a driving one.

1.1.5 The value of (K) must be rounded off to the second decimal place.

1.1.6 For instance: in the case of a twin axle vehicle, the front axle brake having been applied (1), the value of (K) is given by the following formula:

$$K = \frac{z_m \cdot P - 0.015 \cdot P_2}{P_1 + h/E \cdot z_m \cdot P}$$ where

- P is the vehicle weight
- P_1 is the normal reaction of the road on axle 1 in static mode
- P_2 is the normal reaction of the road on axle 2 in static mode
- h is the height of the vehicle's centre of gravity in relation to the ground
- E is the wheelbase
- z_m is the maximum deceleration rate

1.2 Determination of the adhesion utilised (ϵ)

1.2.1 The adhesion utilisation (ϵ) is defined as the quotient of maximum braking rate (z_{max}) when the ABS is in operation and the coefficient of friction (K):

$$\epsilon = \frac{z_{max}}{K}$$

1.2.2 The maximum braking rate (z_{max}) must be determined when ABS is in operation, using the mean value resulting from three tests, the time taken to reduce speed from 40 to 20 km/h being measured according to paragraph 1.1.3 above.

1.2.3 The value of ϵ must be rounded off to the second decimal place.

1.2.4 In the case of a vehicle with all axles equipped with ABS, the z_{max} value must be assessed with the brakes fully applied and the ABS in operation; the adhesion utilisation (ϵ) is determined from the same formula as in paragraph 1.2.1 above.

1.2.5 In the case of a vehicle with only some axles equipped with ABS, the z_{max} value must be determined on each axle with at least one directly controlled wheel.

For example, for a twin axle vehicle with an ABS operating only on the rear axle (2), the adhesion utilisation (ϵ) will be calculated by the following formula:

$$\epsilon = \frac{z_{max} \cdot P - 0.010 \cdot P_1}{K \cdot (P_2 - h/E \cdot z_{max} \cdot P)}$$

This calculation must be made for each axle with at least one directly controlled wheel.

2. MEASUREMENT PROCEDURE FOR TOWED VEHICLES

2.1 When all axles have at least 1 wheel under direct control:

2.1.1 The test must be carried out using the brake on one axle at a time; the brakes must not be applied to the other axles and the prime mover engine must be in neutral.

2.1.2 The braking rate (z) must be determined taking into account the rolling resistance of the axles not subjected to braking. The test must be performed at a speed of 50 km/h and the rolling resistance coefficient can be assumed to be 0.01.

2.1.3 The following ratio must be checked for each axle:

$$\epsilon = \frac{z_1}{z_0} \geq 0.75 \quad \text{where}$$

- ϵ is the adhesion utilised
- z_0 is the maximum braking rate produced when applying the brakes to one axle without locking the wheels, the ABS being disconnected
- z_1 is the braking rate produced by applying the brakes to the same axle on the same surface with the ABS working

The z_1 and z_0 values must be the arithmetic means of 3 values measured successively in the same conditions.

2.2 When the axles do not all have a directly-controlled wheel:

2.2.1 In the case of full trailers, the coefficient of adhesion (K) and the adhesion utilisation (ϵ) must be determined in accordance with the specifications for motor vehicles (see items 1.1 and 1.2 of this Annex); the coupling strain must be taken into account.

2.2.2 In the case of semi-trailers (and of central axle trailers), the following procedure must be used.

2.2.2.1 The adhesion utilisation must be calculated according to the formula below:

$$\epsilon = \frac{z_{max}}{z_0} \quad \text{where}$$

- z_0 is the maximum braking rate obtained by applying the brakes to one axle without causing wheel lock-up (locking), the ABS being disconnected and the wheels on the other axles taken off

- z_{max} is the braking rate obtained by applying the brakes to all axles controlled by the ABS, the latter in the operational mode

2.2.2.2 The z_0 value can be calculated following the procedure described under item 1.1.3 of the present Annex to determine the maximum braking rate (z^*).

In such a case: $z_0 = \frac{T_R}{P_{Rdyn}}$ where

- T_R is the braking force = $z^* \cdot (P + P_M) - 0.01 \cdot W$

- P_M is the total normal reaction of the road on all prime mover axles in static mode

- P is the vehicle weight

- W is the static weight of the unbraked axles

- P_{Rdyn} is the dynamic load

$$P_{Rdyn} = P_R - \frac{T_R \cdot h_s + P \cdot z^* (h_r - h_s)}{E_R}$$

- P_R is the total normal reaction of the road on all trailers or semi-trailers axles
- h_s is the height of fifth wheel
- h_r is the height of trailer centre of gravity
- E_R is the distance of pintle to the semi-trailer axle

2.2.2.3 The z_{max} value can be calculated following the procedure in paragraph 2.2.2.2 above.

- measure z^{**} which is the braking rate with the ABS in the operational mode
- calculate T'_R and P'_{Rdyn} using the formulae of item 2.2.2.2 above, thus:

$$z_{max} = \frac{T'_R}{P'_{Rdyn}}$$

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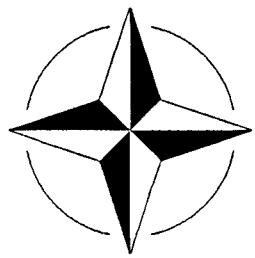

NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : PERFORMANCE

TEST TITLE : SPEED AND ACCELERATION

REFERENCE : STANAG 4357
STANAG 4358

EQUIVALENT : WEU 4FT6 NO.: TM 03-50
ITOP NO.: 2-2-602 (1)

FOR COMPLIANCE WITH : -

ABSTRACT : This AVTP describes how to determine the capability of a vehicle to move from one point to another and to trail in convoy.

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DATE : SEP. 1991

NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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FOR THE MILITARY AGENCY OF STANDARDIZATION

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RECORD OF CHANGES, AMENDMENTS AND RESERVATIONS *)

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Trial Series: PERFORMANCE

Test Title : SPEED AND ACCELERATION

Paragraph

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1. SCOPE

This AVTP describes the trials methods which determine the time taken by a vehicle to go from one point to another and to evaluate its capability of moving in convoy.

The tests used to assess these parameters are as follows:

- maximum speed
- minimum speed
- acceleration
- acceleration from a stabilised speed.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

- track:
  . straight
  . hard surface, good grip
  . sufficient length to allow maximum speed to be reached an sustained, followed by deceleration
  . for the track as a whole: slope ≤ 1 %
    side slope ≤ 2 %

2.2 Instrumentation

DEVICES FOR MEASUREMENT OF:	PERMISSIBLE ERROR OF MEASUREMENT*
a. Speed	1 %
b. Time	1 %
c. Distance	2 %
d. Engine speed	2 %
e. Meteorological data:	
- atmospheric pressure	1 %
- ambient temperature	1°C
- humidity	3 %
- wind speed	5 %
- wind direction	50 mrad

f. Tyre pressure	10 kPa
g. Tyre or track pad wear	0.5 mm

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement in 20.

3. REQUIRED TEST CONDITIONS

3.1 Test vehicle

Ensure that:

a. The vehicle has been prepared and equipped in accordance with standard use and with the specifications laid down in the test plan.

b. The vehicle is in the load condition mentioned in the test plan. The vehicle has been serviced so that it functions according to the manufacturer's specifications.

c. Reference fuels and lubricants as specified by relevant NATO Authority (after ratification) have been used. Until NATO agreement is ratified, developer specified POL will be used.

d. The proper quantities of lubricants have been used.

e. The tyre pressures are correct (for wheeled vehicles).

f. Track tension is correct (for tracked vehicles).

g. Windows and air vents are properly closed and tarpaulins well lashed down.

h. Normal operating temperature of fluids and components are reached before testing begins.

i. Vehicle tracks or tyres are in good condition.

3.2 Test course

Clean, dry track.

3.3 Environment

- wind speed	: $\leq$ 5 m/s
- desirable ambient temperature	: 5 °C $\leq \theta \leq$ 35 °C
- desirable atmospheric pressure	: Pa $\geq$ 91 kPa
- humidity	: $\leq$ 95 %

4. TEST PROCEDURE

4.1 Maximum speed

a. Take the vehicle up to maximum speed for the selected gear ratio.

b. Measure vehicle and engine speeds, when the vehicle speed has been stabilised at full throttle.

c. The test should be carried out three times in each track direction.

4.2 Acceleration - Starting with engine idling

a. Starting position:
- . engine idling, transmission disengaged, use gear ratio corresponding to the best performance
- . brakes off.

b. Accelerate the vehicle as quickly as possible using the transmission and the engine to the best effect.

c. Measure time, vehicle speed, distance covered and, if required, engine speed and vehicle acceleration.

d. The test should be carried out three times in each track direction.

4.3. Acceleration - Starting at high engine speed (optional)

a. Starting position:
- . brakes on
- . accelerate the engine until the required engine speed is reached
- . release the brakes sharply while keeping full throttle.

b. Accelerate the vehicle as quickly as possible using the transmission and the engine to the best effect.

c. Measure time, vehicle speed, distance covered and, if required, engine speed and vehicle acceleration.

d. The test should be carried out three times in each track direction.

4.4 Acceleration from one predetermined to another speed (optional test)

a. Stabilise the vehicle at the speed and gear ratio required by the test plan.

b. Depress the accelerator rapidly to reach to the full throttle position until the second specified speed is reached or until a sufficient distance has been covered in the gear ratio.

c. Measure time, vehicle speed, distance covered and, if required, engine speed and vehicle acceleration.

d. The test should be carried out three times in each track direction.

4.5 Minimum speed

a. Use the lowest ratio of the drive system without declutching.

b. Adjust the engine speed commensurate with smooth running and without any perturbation causing variations in instantaneous speed greater than 0.5 km/h.

c. Measure vehicle and engine speed.

d. The test should be carried out three times in each track direction.

5. DATA REQUIRED

5.1 General parameters

- vehicle identification:
  . weight distribution
  . odometer or hourmeter reading.

- note parameters to be checked, as laid down in the test plan (tyre wear and pressure, track tension).

- weather conditions:
  . temperature
  . atmospheric pressure
  . humidity
  . wind speed and direction.

5.2 Results of tests

Note for each test:
- the test number
- the direction of the track
- the speed
- the engine speed (desirable)
- the transmission ratios
- the distance covered
- the acceleration (if required).

6. PRESENTATION OF DATA

Present the required data in narrative, tabular, graphical, pictorial and other format as appropriate.

Include:

6.1 Maximum speed

- give best performance in each track direction: speed, engine speed and gear ratio.

AVTP : 03-50
EDITION NO.: FINAL
DATE : SEP. 1991

6.2 Acceleration

- give the best performance in each track direction, set out as follows:
  . speed as a function of time and distance travelled
  . distance as a function of time
  . acceleration as a function of time (optional)
  . engine speed as a function of time.

6.3 Acceleration from one predetermined to another

- as for paragraph 6.2.

6.4 Minimum speed

- give the best performance in each track direction: speed, engine speed and gear ratio.

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VEHICLE TESTING
PUBLICATION

AVTP : 03-60
EDITION NO. : FINAL
DATE : MAY 1994

NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : PERFORMANCE

TEST TITLE : DRAWBAR PULL AND RESISTANCE TO MOTION ON HARD SURFACE

REFERENCE : STANAG 4357
STANAG 4358

EQUIVALENT : WEU 4FT6 NO.: TM 03-60 A
ITOP NO.: 2-2-604 (3)

FOR COMPLIANCE WITH : -

ABSTRACT : This AVTP describes procedures for measuring the drawbar pull and the force required to move the test vehicle on hard surface.

03.05.94

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EDITION NO.: FINAL
DATE : SEP. 1991

NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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FOR THE MILITARY AGENCY OF STANDARDIZATION

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*) See Reservations Overleaf

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Trial Series: PERFORMANCE

Test Title : DRAWBAR PULL AND RESISTANCE TO MOTION ON HARD SURFACE

Paragraph

AVTP : 03-60
EDITION NO.: FINAL
DATE : SEP. 1991

1. SCOPE

This document describes trials methods for measuring:
- the drawbar pull
- the force required to move the test vehicle.

The measurement of drawbar force makes it possible to determine the power available in addition to that used for propelling the vehicle.

The total resistance as measured by the deceleration method is a measure of amount of energy required for the vehicle to propel itself at any given speed.

The total energy needed to propel the vehicle is made of two separate parts:
- rolling resistance
- wind resistance.

Measurement of the rolling resistance force makes it possible to determine the energy absorbed in overcoming the towing resistance of the vehicle.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

a. Dynamometer vehicle or equivalent.
b. Track:
   . Hard surface with good grip.
   . Flat and straight surface (gradient ≤ 1 %, side slope ≤ 2 %).

2.2 Instrumentation

DEVICES FOR MEASUREMENT OF:	PERMISSIBLE ERROR OF MEASUREMENT*
a. Force	2 %
b. Speed	1 %
c. Time	1 %

d. Engine speed (if required)	2 %
e. Fuel temperature (if applicable)	1 °C
f. Tyre pressure	10 kPa
g. Tyre wear	0.5 mm
h. Ambient temperature	1 °C
i. Relative humidity	3 % of full scale
j. Air pressure	1 %

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement of 20.

3. REQUIRED TEST CONDITIONS

3.1 Test vehicle

Ensure that:

a. The vehicle is prepared and equipped to the standard anticipated for operations or as specified by the test plan.

b. Maintenance and service operations have been performed to ensure that the vehicle is operating within the manufacturer's specification. Give particular attention to the engine, transmission, and running gear.

c. Reference fuels and lubricants as specified by relevant NATO authority (after ratification) have been used. Until NATO agreement is ratified, developer-specified POL will be used.

d. The proper quantities of lubricants have been used.

e. Normal operating temperatures of fluids and components are reached before testing begins.

f. Nominal value of stall engine speed*) is maintained, if applicable.

*) Stall engine speed is the stabilized engine speed (for engines connected to a hydraulic torque converter) with the accelerator pedal fully depressed and the vehicle held stationary.

g. Vehicle tracks/tyres are in good condition and properly adjusted/inflated and maintained during testing.

h. The power train of the test vehicle is disconnected for the "resistance to motion tests".

3.2 Test course

- Clean, dry track.

3.3 Environment

- wind speed : $\leq$ 5 m/s
- desirable ambient temperature : 5 °C $\leq \theta \leq$ 35 °C
- desirable atmospheric pressure: $\geq$ 91 kPa
- relative humidity : $\leq$ 95 %

4. TEST PROCEDURE

4.1 Drawbar pull

a. The test vehicle draws a dynamometer vehicle, of adequate capacity to restrain the test vehicle.
The accelerator of the test vehicle should be at full throttle and remain in this position until the end of the test run.

b. The dynamometer force is then increased until the reference value (force or speed) is obtained. The reference value should be defined in the trials programme.

c. This force is sustained over a distance sufficiently great to stabilise all parameters (the variation with respect to the standard parameter must be less than 10 %).

d. Record the parameters.

e. Repeat the test twice for each reference parameter.

f. Repeat the test for each gear ratio stipulated in the trials programme.

4.2 Rolling resistance - Towing method

a. Disengage the test vehicle's transmission.

b. Tow the vehicle using a dynamometer vehicle.

c. Measure the force for below 15 km/h speed in increments.

d. Repeat the test, in each track direction, for each speed range.

4.3 Total resistance - Deceleration method

a. Stabilise the vehicle at its maximum speed.

b. Disengage the transmission and allow the vehicle to coast to rest.

c. Measure the speed of the vehicle and time throughout the test.

d. Determine total resistance from the vehicle mass and from deceleration calculated for each speed in question.

e. Repeat the test twice in each direction of the track.

5. DATA REQUIRED

a. Vehicle identification:
- weight distribution
- mileage

b. Drawbar/Towing force

c. Vehicle speed

d. Engine speed

e. Gear range

f. Vehicle weight

g. Time

h. Fuel temperature (if applicable)

i. Tyre pressure and wear

j. Track pad wear

k. Weather conditions:
- Air pressure
- Air temperature
- Relative humidity

6. PRESENTATION OF DATA

Present the required data in narrative, tabular, graphical, pictorial or other format as appropriate.

Include:

6.1 Drawbar pull

Drawbar force versus vehicle or engine speed for each gear used (as appropriate).

6.2 Rolling resistance

Force versus speed.

6.3 Total resistance

Force versus speed.

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VEHICLE TESTING
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AVTP : 03-70
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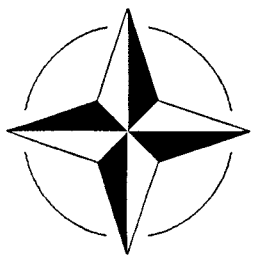

NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : PERFORMANCE

TEST TITLE : POWER LOSSES

REFERENCE : STANAG 4357
STANAG 4358
AVTP 03-50
AVTP 03-60

EQUIVALENT : WEU 4FT6 No.: TM 03-70

FOR COMPLIANCE WITH : -

ABSTRACT : This AVTP describes procedures for evaluating the power losses of a vehicle before and after a period of use.

8.91

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EDITION NO.: FINAL
DATE : SEP. 1991

NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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Trial Series: PERFORMANCE

Test Title : POWER LOSSES

Paragraph

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1. SCOPE

The aim of these tests is to compare the performance of a vehicle before and after a period of use. In order to determine any power loss caused by this utilisation, one of the following tests should be carried out:

Acceleration
Drawbar Pull
Power available at the wheels or sprockets.

This document only describes the last of these, i.e. Power available at the wheels or sprockets.

"Acceleration" and "Drawbar Pull" are dealt with in AVTPs 03-50 and 03-60 respectively.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

- Dynamometer (if a roller dynamometer is used, it is desirable that the diameter of the roller should be ≥ 1.5 m)

2.2 Instrumentation

DEVICES FOR MEASUREMENT OF:	PERMISSIBLE ERROR OF MEASUREMENT*
a. Torque at the Wheels or Sprockets	2 %
b. Angular Speed of Wheels or Sprockets	2 %
c. Engine Speed	2 %
d. Ambient Temperature	1 °C
e. Atmospheric Pressure	1 %
f. Relative Humidity	3 % of full scale
g. Tyre Wear	0.5 mm

h. Tyre Pressure 10 kPa

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement of 20.

3. REQUIRED TEST CONDITIONS

3.1 Test Vehicle

Ensure that:

a. The vehicle has been prepared and equipped in accordance with the standard use and with the specifications laid down in test plan.

b. The vehicle is in the load condition mentioned in the test plan. The vehicle has been serviced so that it functions according to the manufacture's specifications.

c. Reference fuels and lubricants as specified by relevant NATO Authority (after ratification) have been used. Until NATO agreement is ratified, developer specified POL will be used.

d. The proper quantities of lubricants have been used.

e. The tyre pressures and track tension are correct.

f. Normal operating temperature of fluids and components are reached before testing begins.

g. The conditions of tyres and tracks are noted if they are not in the condition as originally tested.

3.2 Environment

All tests should be carried out under similar environmental conditions.

AVTP : 03-70
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DATE : SEP. 1991

4. TEST PROCEDURE

4.1 Reference and Final Power Losses Tests

One of the tests defined paragraphs 4.2, 4.3 and 4.4 is to be conducted before and after the utilisation laid down in the trials programme.

4.2 Acceleration

See AVTP 03-50.

4.3 Drawbar Pull

See AVTP 03-60.

4.4 Power Losses

- For each ratio of the gear box and transfer box, laid down in the trials programme, carry out the following operations:
  . Place the accelerator in the full throttle position
  . Apply the torque to the wheels or sprockets and determine the corresponding engine speed.

- Apply a sufficient number of increments of torque to the wheels (or sprockets) to enable a graph of wheel or sprocket power versus engine speed to be drawn.

5. DATA REQUIRED

5.1 General Parameters

- Vehicle identification:
  . Weight distribution
  . Mileage.

- Note parameters to be checked, as laid down in the test plan (tyre wear and pressure, track tension, if applicable).

- Environmental conditions:
  . Temperature
  . Atmospheric pressure
  . Relative humidity

- Dynamometer or roller dynamometer characteristics, as appropriate.

5.2 Acceleration and Drawbar Pull

See AVTPs 03-50 and 03-60.

5.3 Power Losses

Note for each test:
- the test number
- the angular speed of wheels or sprockets
- the engine speed
- the transmission ratios used
- torque at the wheels or sprockets.

6. PRESENTATION OF DATA

Present the required data in narrative, tabular, graphical, pictorial and other format as appropriate.

6.1 Acceleration and Drawbar Pull

See AVTPs 03-50 and 03-60. Results obtained before and after the utilisation defined by the test programme must be included.

6.2 Power Losses

Graphs of power at the wheels or sprockets versus engine speed before and after the utilisation defined by the test programme must be included.

ALLIED
VEHICLE TESTING
PUBLICATION

AVTP : 03-80
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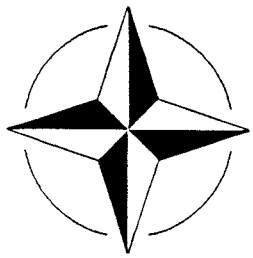
DATE : SEP. 1991



NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : PERFORMANCE

TEST TITLE : OBSTACLES

REFERENCE : STANAG 4357
STANAG 4358

EQUIVALENT : WEU 4FT6 NO.: TM 03-80

FOR COMPLIANCE WITH : -

ABSTRACT : This AVTP describes how to verify the performance of wheeled and track vehicles when negotiating obstacles.

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DATE : SEP. 1991

NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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FOR THE MILITARY AGENCY OF STANDARDIZATION

(Signature)

AVTP : 03-80
EDITION NO.: FINAL
DATE : SEP. 1991

RECORD OF CHANGES, AMENDMENTS AND RESERVATIONS *)

Identification of Change or Amendment and Reg.No.(if any) and date	Date Entered	NATO Effective Date	By whom entered Signature, Rank, Grade or Rate, Name of Command

*) See Reservations Overleaf

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DATE : SEP. 1991

Trial Series : PERFORMANCE

Test Title : OBSTACLES

Paragraph

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1. SCOPE

This document describes methods of evaluating the performance of vehicles when negotiating concave and convex obstacles.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities (See Annex A)

a. Vertical-sided ditches of sufficient depth (e.g. concrete trenches)

b. Vertical walls (varying heights)

c. Steps

d. Other obstacles (V-shaped ditches, tree trunks ...)

2.2 Instrumentation

DEVICES FOR MEASUREMENT OF:		PERMISSIBLE ERROR OF MEASUREMENT*
a.	Distance	0.3 %
b.	Tyre pressure	10 kPa
c.	Angles	10 mrad

Whenever possible, still or motion photography should be used to record the vehicle negotiating the obstacles.

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement of 20.

3. REQUIRED TEST CONDITIONS

3.1 Test Vehicle

Ensure that :

a. Load carrying vehicles carry real or simulated loads. Simulated loads must have the same rigidity, weight and centre of gravity as real loads. Load shifting should be minimized during obstacle negotiation, unless such shifting is a characteristic of the system design.

b. Maintenance has been carried out so that the vehicle functions according to manufacturer's instructions. In particular, engine, transmission, suspension and running gear must be checked.

c. The gun (if any) is in transport position or in an operational configuration (if required).

d. The tyres are in good condition and at the correct pressure.

e. The track pads are in good conditions and tracks correctly tensioned.

f. The operating temperature of the various components has been reached immediately prior to the test.

3.2. Test Area

The test area must be clean and dry unless otherwise specified in the test plan.

4. TEST PROCEDURE

4.1 General Instructions

a. Obstacles are always negotiated from rest at the foot of the obstacle.

b. In principle, the vehicle always faces the obstacles at an angle of 90°: obstacles can also be negotiated at angles other than 90° if so desired and stated in the test plan.

c. Trials to verify the obstacle crossing capability of only one side of the vehicle(left or right wheels/tracks) are optional.

4.2 Gap Crossing (See Figure 1a in Annex A)

To be established as follows:

a. Leave a far smaller gap between the walls of the ditch to be crossed than the vehicle is expected to be capable of negotiating. Negotiate the ditch at minimum speed.

b. Gradually widen the gap until the vehicle's maximum gap crossing width is reached. Repeat test twice when this limit is reached and record the best result.

c. Determine the gap crossing limit moving forward and, if necessary, in reverse.

4.3 Crossing Walls and Steps (See figure 1b and 1c in Annex A)

Start with an obstacle of severity considerably less than that which the vehicle is expected to be capable of negotiating.

Place the vehicle so that the front wheels or front part of the tracks touch the obstacle at a 90° angle. Accelerate sufficiently to cross the obstacle. This test is successful only if the whole vehicle crosses the obstacle. Carry out the test moving both forwards and in reverse. Record any contact between vehicle and obstacle or ground. Gradually increase the height of the obstacle and repeat the test until the limit of the vehicle's obstacle crossing capability is reached. When the maximum height is reached, repeat the test twice and record the test result. It required the test should be repeated with the vehicle descending the steps.

N.B. :If the steering has to be used during wall or step crossing (other than for keeping the vehicle perpendicular to the obstacle) the test results are not valid.

4.4 Other Obstacles

Additional obstacles may be used to test the capability of the vehicle, some examples of which are given in Annex A page A-2.

5. Data Required

5.1 General Data

a. Gear ratio used, number of driving wheels, longitudinal or transverse locking of differentials, vehicle load state.

b. Initial position of the vehicle with respect to the obstacle (90°, sideways, left or right only, forward or reverse movement).

c. Pressure and wear of tyres.

d. Elevation and azimuth position of gun (if required).

5.2 Gap Crossing Width

a. Maximum width negotiated forward and, if necessary, in reverse.

b. Comments on any parts of the vehicle which touched the edges of the gap.

5.3 Crossing Walls and Steps

a. Geometric description of walls and steps (height and width).

b. Maximum height crossed together with direction (up/down, forward/reverse).

c. Comments on any parts of the vehicle which touched the walls, steps or the ground.

d. Factors limiting the negotiation of larger obstacles (Available power, vehicle contact, tyre or track slip if determined, etc).

5.4 Other Obstacles (if any)

a. Geometric description of obstacle together with a drawing.

b. Negotiating limits.

c. Comments on any parts of the vehicle which touched the ground or the obstacle.

d. Factors limiting the negotiating of larger obstacles, if determined.

6. PRESENTATION OF DATA

Present the required data in narrative, graphical, pictorial or other format as appropriate.

Include:

a. Table of results.

b. Photographs of the most important parts of the tests.

AVTP : 03-80
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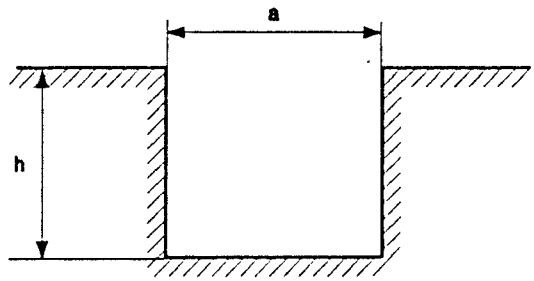
ANNEX A

1. Straight-walled ditches, walls, steps.

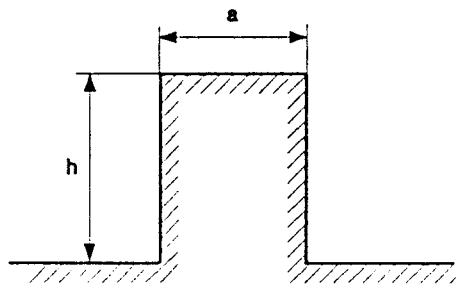
a. Straight-walled ditches:



Geometric characteristics: a, h

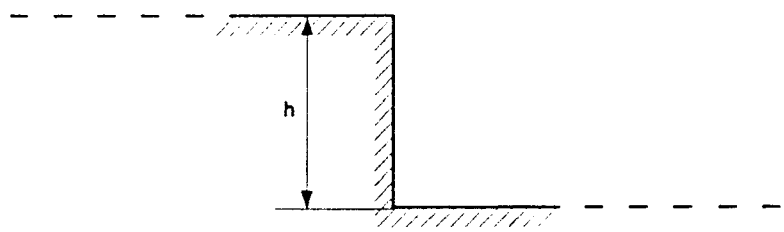
Note: h must be sufficiently large that no part of the vehicle touches the bottom.

b. Walls:



Geometric characteristics: a, h and $a \leq h$

c. Steps:



Geometric characteristics: h

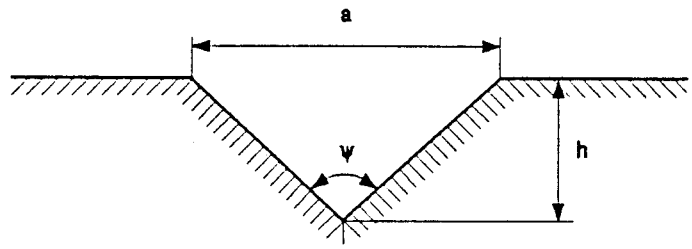
AVTP : 03-80
EDITION NO.: FINAL
DATE : SEP. 1991

ANNEX A

2. Other types of obstacles

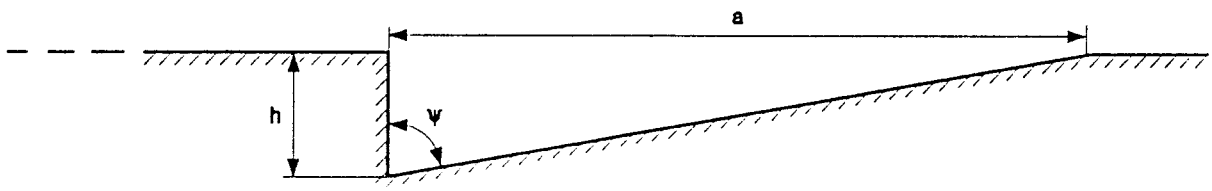
In addition to the above obstacles, the obstacle-negotiating ability of a vehicle can be evaluated using other obstacles including:

a. V-shaped:



Geometric characteristics: a, h, ψ

b. Inclined step:

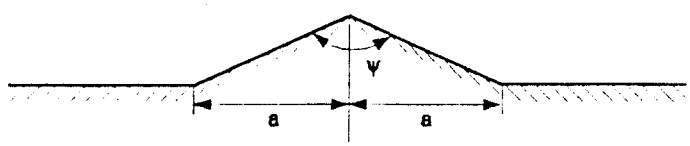


Geometric characteristics: a, h, ψ

c. Tree trunks laid at right angles to the vehicle's driving direction. Geometric characteristics:

- Number of tree trunks
- Diameter of tree trunks
- distance between tree trunks

d. Belly clearance gauge



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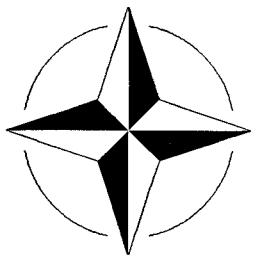

NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : PERFORMANCE

TEST TITLE : GRADIENTS AND SIDE-SLOPES

REFERENCE : STANAG 4357
STANAG 4358

EQUIVALENT : WEU 4FT6 NO.: TM 03-90
ITOP.: 2-2-610 (1)

FOR COMPLIANCE WITH : -

ABSTRACT : This AVTP describes how to determine the performance of wheeled and tracked vehicles on gradients and side-slopes.

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EDITION NO.: FINAL
DATE : MAY 1992

NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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FOR THE MILITARY AGENCY OF STANDARDIZATION

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AVTP : 03-90
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RECORD OF CHANGES, AMENDMENTS AND RESERVATIONS *)

Identification of Change or Amendment and Reg.No.(if any) and date	Date Entered	NATO Effective Date	By whom entered Signature, Rank, Grade or Rate, Name of Command

*) See Reservations Overleaf

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Test Title : GRADIENTS AND SIDE-SLOPES

Paragraph

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EDITION NO.: FINAL
DATE : MAY 1992

1. SCOPE

This document describes methods of evaluating the performance of wheeled and tracked vehicles on various grades and side-slopes.

Trials on grades will show whether the vehicle has sufficient power and traction to negotiate the grade without loss of adhesion.

Trials on grades and side-slopes also serve to check the vehicle's stability and controls, as well as the proper functioning of systems under these conditions.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

a. Grades, of known constant gradients up to 60 %, possessing surface of sufficient friction.

b. Side slopes, of known constant gradients up to 40 %, possessing surface of sufficient friction.

c. Tilting Platform.

2.2 Instrumentation

DEVICES FOR MEASUREMENT OF:		PERMISSIBLE ERROR OF MEASUREMENT*
a.	Distance	2%
b.	Vehicle speed	1%
c.	Time	1%
d.	Meteorological data :	
	- atmospheric pressure	1%
	- ambient temperature	1°C
	- relative humidity	3%
e.	Tyre pressure	10 kPa

f.	Tyre wear/ Track pad wear	0.5 mm
g.	Angle	10 mrad
h.	Data on mechanical components:	
	- engine speed	5%
	- oil pressure	5%
	- coolant temperature	1°C

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors must not be exceeded in more than 1 measurement of 20.

3. REQUIRED TEST CONDITIONS

3.1 Test Vehicle

Ensure that:

a. The vehicle is carrying its normal full or combat load, with the overall centre of gravity of the vehicle at its proper location, unless otherwise stated.

b. Maintenance has been carried out so that the vehicle functions as per manufacturer's instructions. In particular, check engine, transmission, running gear and brakes.

c. Reference fuels and lubricants as specified by the relevant NATO authority (after ratification) have been used. Until NATO agreement is ratified, developer-specified POL will be used.

d. Engine and transmission oil levels are at the levels specified by the manufacturer or as specified in the test plan.

e. Vehicle tyres or track pads are in good condition; tyres are at the pressures laid down by the manufacturer or as specified in the test plan.

f. The fuel tank is full or filled to 25 % capacity, or as specified by the test plan.

g. Fluids and components are at their normal working temperatures before starting the trial.

h. The payload is secured in the manner specified by the manufacturer or the test plan.

3.2 Test course

The test course must be clean and dry throughout testing.

4. TEST PROCEDURE

4.1 Systems Performance on Transverse and Longitudinal Slopes

The performance of fueling, cooling and lubrication systems on adverse gradients specified in the test plan (fore-and-aft, to left and to right) can be verified by the following procedure:

a. Position the vehicle on the appropriate grade or side slope, with engine running, transmission in neutral, parking brake applied.

b. Run the engine at idle speed for 10 minutes, or for a duration stated in the test plan.

c. Run the engine at a speed corresponding to maximum torque for 5 minutes, or for a duration stated in the test plan.

d. Stop the engine and wait for 2 minutes.

e. Run the engine at idle speed for 2 minutes, or for a duration stated in the test plan.

f. During (b), (c) and (e) monitor engine speed, oil pressure, coolant temperature. Record any adverse occurrences (eg. loss of oil pressure or excessive oil pressure, changes in engine speed, overheating, excessive smoke or leaks).

g. Take the vehicle off the grade or side slope.

h. Repeat on any other grades or side slopes required by the test plan.

i. The above procedure (a) to (h) is to be carried out in the following conditions:

- fuel tank full, oil level at maximum
- fuel tank filled to 25 % of its capacity, oil level at minimum
- any other fuel and oil levels required by the test plan.

j. The above procedure (a) to (i) is to be repeated for auxiliary engine, if fitted and required by the test plan.

4.2 Maximum Gradient Climbing Ability

a. Position the vehicle before the start of the least severe test grade specified in the test plan.

b. Use maximum forward acceleration to reach the highest climbing speed. Record which is the highest gear that could be used to maintain this speed up the gradient, and, if required, record the speed maintained.

c. If required, carry out further test runs to ensure that the optimum gear ratios are being used.

d. Repeat (a) to (c) for all other gradients specified in the test plan, in increasing order of steepness, to establish the steepest test grade that can be climbed.

e. Repeat (a) to (d) for all other vehicle load states laid down in the test plan.

f. Repeat (a) to (e) with vehicle reversing up the grade, if required by the test plan (safety note: not on articulated vehicles or trailers).

4.3 Maximum Gradient Holding and Starting Ability

a. Drive the vehicle forwards up onto the least severe grade specified in the test plan. Stop the vehicle with the service brakes, and while holding the vehicle stationary with the service brakes, put the transmission in neutral.

b. Apply the parking brakes and release the service brakes; thus verify that the parking brakes can independently hold the vehicle on the grade (engine running for safety).

c. Using normal hill-start procedures, verify that the vehicle can move off forwards and continue up off the slope.

d. Repeat (a) to (c) for all other gradients specified in the test plan, in increasing order of steepness.

e. Repeat (a) to (d) for all other vehicle load states laid down in the test plan.

f. Repeat (a) to (e) with vehicle reversing up the grade, if required by the test plan (safety note: not on articulated vehicles or trailers).

4.4 Static Transverse Tilt Test

Note: This test, as well as being a test in its own right, should, for safety reasons, be carried out before attempting the tests given in paragraphs 4.1 and 4.5 .

a. Place the vehicle, in the load state required by the test plan, on a tilting platform. Tilt the platform (so that the vehicle is tilted sideways) until vehicle instability occurs.
Record the platform angle at which:

- First wheel lift occurs

- Vehicle overturn occurs (vehicle must be restrained).

b. Return the platform to the horizontal and take the vehicle off.

c. Repeat (a) to (b) with the vehicle tilted to the other side.

d. Repeat (a) to (c) for all other vehicle conditions specified in the test plan (eg. different loads, different orientations of turret, etc).

4.5 Driving Performance on Side Slopes

a. Drive the vehicle and attempt to follow a straight line at a stabilised speed of approximately 5 km/h along the least severe side slope stated in the test plan. Note vehicle behaviour.

b. Repeat (a) in the opposite direction of travel.

c. Repeat (a) to (b) at higher stabilised speeds stated in the test plan.

d. Repeat (a) to (c) on all steeper side slopes stated in the test plan, in increasing order of severity.

e. If required by the test plan, repeat (a) to (d) but this time steering the vehicle up and down the slope in a sinusoidal pattern.

f. Repeat (a) to (e) in all other vehicle load states required by the test plan.

5. DATA REQUIRED

5.1 Systems Performance on Transverse and Longitudinal Slopes

a. Vehicle load configuration and weight.

b. Fuel and oil levels.

c. Angle of grade or side slope.

d. Direction of grade or side slope.

e. Engine speeds:

- maximum torque
- idle

f. Duration of engine running.

g. Oil pressure.

h. Coolant temperature.

i. Notes of any adverse occurrences.

5.2 Maximum Gradient Climbing Ability

a. Vehicle load configuration and weight.

b. Angle of gradient.

c. Direction (forward or reverse up gradient).

d. Transmission gear used to maintain climb.

e. Climbing speed.

5.3 Maximum Gradient Holding and Starting Ability

a. Vehicle load configuration and weight.

b. Angle of gradient.

c. Direction (forward or reverse up gradient).

d. Transmission gear used to restart climb.

e. Comments on:

- service and parking brake effectiveness
- vehicle behaviour when restarting climb.

5.4 Static Transverse Tilt Test

a. Vehicle load configuration and weight.

b. Tyre pressures.

c. Direction of tilt (left or right).

d. Platform angle to:

- 1st wheel lift
- vehicle overturn.

e. Vehicle body angles (front and rear) at 1st wheel lift.

5.5 Driving Performance on Side Slopes

a. Vehicle load configuration and weight.

b. Tyre pressures, tyre or track pad condition.

c. Angle and direction of side slope.

d. Vehicle speed.

e. Vehicle path (straight line, sinusoidal).

f. Comments on vehicle behaviour.

6. PRESENTATION OF DATA

Present the required data in narrative, tabular, graphical, pictorial or other format as appropriate.

ALLIED
VEHICLE TESTING
PUBLICATION

AVTP : 03-100
EDITION NO.: FINAL
DATE : SEP. 1991

NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : PERFORMANCE

TEST TITLE : SOFT SOIL MOBILITY

REFERENCE : STANAG 4357
STANAG 4358

EQUIVALENT : WEU 4FT6 NO.: TM 03-60B
ITOP NO.: 2-2-604(1)
ITOP NO.: 2-2-605(1)
ITOP NO.: 2-2-619(1)

FOR COMPLIANCE WITH : -

ABSTRACT : This AVTP describes testing procedures required to assess comparative soft-soil mobility characteristics of Combat and Transport Vehicles.

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NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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Trial Series: PERFORMANCE

Test Title : SOFT SOIL MOBILITY

Paragraph

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EDITION NO.: FINAL
DATE : SEP. 1991

1. SCOPE

This document describes testing procedures required to assess comparative soft-soil mobility characteristics of vehicles. Whereas operation over hard surfaces is normally not a mobility problem, off-road operation over soft-terrain media such as sand, loam, mud, snow and swamps usually does create locomotion difficulties of varying degrees. Drawbar pull on soft soil represents the power available beyond that required to overcome soft-terrain power losses such as track/wheel slippage, ground resistance to motion, and hull drag resistance. In a comparative sense, test-vehicle performance is quantified for soft-soil crossing capability in order to determine the most efficient track, tyre (including tyre pressure), suspension, and hull designs. Off-road mobility problems created by brush, trees an other obstacles are not covered by this procedure, nor is the interrelationship of manoeuvrability and mobility addressed.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

a. Mobile field dynamometer or equivalent

b. Test courses:
   (1) Sand
   (2) Fine-grained soil courses, as required
   (3) Natural terrain, as required

2.2 Instrumentation

DEVICES FOR MEASUREMENT OF:	PERMISSIBLE ERROR OF MEASUREMENT*
a. Drawbar force	2%
b. Vehicle speed	1%
c. Engine, sprocket, wheel and cooling fan speeds (if applicable)	2%
d. Time	1%

e.	Cone index	10%
f.	Soil moisture content	2%
g.	Soil density	5%
h.	Soil depth (to hardpan)	2 cm
i.	Vehicle sinkage	2 cm
j.	Drive-shaft torque (as required)	2%
k.	Tyre pressure	10 kPa
l.	Tyre/pad wear	0.5 mm
m.	Ambient temperature	1 °C
n.	Air humidity	3% of full scale
o.	Air pressure	1%

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement of 20.

3. REQUIRED TEST CONDITIONS

3.1 Test Vehicle

Ensure that:

a. The vehicle is prepared and equipped to the standard anticipated for operations or as specified by the test plan.

b. Maintenance and service operations have been performed to ensure that the vehicle is operating within manufacturer's specifications. Give particular attention to the engine, transmission, and running gear.

c. Reference fuels and lubricants as specified by relevant NATO authority (after ratification) have been used. Until NATO agreement is ratified, developer-specified POL will be used.

d. The proper quantities of lubricants have been used.

e. Normal operating temperatures of fluids and components are reached before testing begins.

f. Nominal value of stall engine speed*) is maintained, if applicable.

g. Vehicle tracks/tyres are in good condition and properly adjusted/inflated and maintained during testing.

h. The power train of the test vehicle for the resistance to tow tests is disconnected.

*)Stall engine speed is the stabilized engine speed, when engine is connected to a hydraulic torque converter with locked turbine, and when the accelerator pedal is fully depressed.

3.2 Test Courses

Soil should be deep tilled to approximately 6o cm, if possible, except when testing over natural terrain not covered by para. 2.1b (1) and (2).

4. TEST PROCEDURES

4.1 Drawbar Pull

The test vehicle pulls a mobile field dynamometer (or equivalent equipment such as a winch) which applies a constant tractive force.
This force is sustained over a distance sufficiently great to stabilise all parameters (speed, slippage).
Several ranges of force are thus applied so as to obtain a graph of force versus slippage. The latter should vary from 0 to 100% if possible.

4.2 Crossing Velocity

Operate the vehicle at fully depressed accelerator pedal in each transmission gear (or range) in each level soft-soil test medium. Record maximum sustained vehicle speed and slippage.

4.3 Acceleration

a. Conduct the necessary trials to determine the optimum transmission gear (or range) shift pattern which provides the minimum acceleration time to maximum speed on each level soft-soil test course.

b. From an engine-idle condition on each test course, starting in the gear (or range) determined in paragraph 4.3a, depress the accelerator pedal rapidly to the fully depressed position and move through the various gear ratios as quickly as possible.

c. Record vehicle speed (or distance), engine speed (as required), drive shaft torque and speed (if applicable), and time at suitable increments to define the characteristic curve.

4.4 Resistance to Propulsion (if applicable)

a. Operate the vehicle at sustained speeds, on each of the soft-soil courses, over as much of the vehicle speed range as possible. For baseline data, operate in the same manner on a level paved surface.

b. Measure drive-shaft torques and slippage at sufficient increments of vehicle speed to delineate resistance to propulsion characteristics for each terrain type.

4.5 Resistance to Towing (if required)

Tow the test vehicle by means of a long cable connected to a dynamometer vehicle at different speeds, so that prepared soil ahead of the tracks or wheels is undisturbed. Record towing force and speed.

5. DATA REQUIRED

a. Drawbar/Towing force.

b. Drive-shaft torque and speed (if applicable).

c. Vehicle speed.

d. Engine speed.

e. Sprocket/Wheel speed.

f. Gear range.

g. Vehicle weight.

h. Vehicle sinkage.

i. Time.

j. Distance, as required.

k. Tyre pressure and wear

l. Pad wear

m. Soil conditions.
   (1) Moisture content.
   (2) Cone-index readings.
   (3) Hardpan depth (CI 150 or greater).
   (4) Depth of tilling.
   (5) Density (fine-grained soils only) as required.
   (6) Soil type - Unified Classification System (fine-grained soils only). See ANNEX A.

n. Weather conditions.
   (1) Air pressure.
   (2) Air temperature.
   (3) Air humidity.

6. PRESENTATION OF DATA

Present the required data in narrative, tabular, graphical, pictorial or other format as appropriate.

Include:

6.1 Drawbar Pull

a. Drawbar force vs. vehicle speed (as appropriate).
b. Drawbar force vs. slippage.
c. Slippage vs. vehicle speed.
d. Engine speed vs. vehicle speed.
e. Drive-shaft torque vs. vehicle speed (if applicable).

f. Drive-shaft torque vs. drive-shaft speed (if applicable).
g. Vehicle sinkage.
h. Table of soil conditions.

6.2 Crossing Velocity

a. Table of results.
b. Table of soil conditions.

6.3 Acceleration

a. Vehicle speed (or distance) vs. time.
b. Drive-shaft torque vs. time (if applicable).
c. Engine speed (as required) vs. time.
d. Table of soil conditions.

6.4 Resistance to Propulsion (if applicable)

a. Drive-shaft torque vs. vehicle speed.
b. Drive-shaft torque vs. drive-shaft speed.
c. Slippage vs. vehicle speed (optional).
d. Table of soil conditions.

6.5 Resistance to Towing (if applicable)

a. Graphical presentation of towing force vs.vehicle towing speed.
b. Table of soil conditions.

Unified Soil Classification System

UNIFIED SOIL CLASSIFICATION (Including Identificatin and Description)

Major Divisions			Group Symbols	Typical Names	Field Identification Procedures (Excluding particles larger than 3 in. and basing fractions on estimated weights.)			Information Required for Describing Soil	Laboratory Classification Criteria
1	2		3	4	5			6	7
Coarse - grained Soils More than half of material is larger than No. 200 sieve size. The No. 200 sieve size is about the smallest particle visible to the naked eye.	Gravels More than half of coarse fraction is larger than No. 4 sieve size (For visual classification, the 1/4-in. size may be used as equivalent to the No. 4 sieve size)	Clean gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.			For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions, and drainage characteristics. Give typical name; indicate approximate percentage of sand and gravel, maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbol in parentheses. Example: Silty sand, gravelly; about 20% hard, angular gravel particles 1/2-in. maximum size; rounded and subangular sand grains, coarse to fine; about 15% nonplastic fines with low dry strength; well compacted and moist in place; alluvial sand; (SM).	Determine percentages of gravel and sand from grain-size curve. Depending on percentage of fines (fraction smaller than No.200 sieve size) coarse - grained soils are classified as follows: Less than 5% GW, GP, SW, SP. More than 12% GM, GC, SM, SC. 5% to 12% Borderline cases requiring use of dual symbols.
			GP	Poorly graded gravels or gravel-sand mixtures, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.				
		Gravels with Fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixture.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below.)				
			GC	Clayey gravels, gravel-sand-clay mixtures.	Plastic fines (for identification procedures see CL below.)				
	Sands More than half of coarse fraction is smaller than No. 4 sieve size	Clean sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines.	Wide range in grain size and substantial amounts of all intermediate particle sizes.				
			SP	Poorly graded sands or gravelly sands, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.				
		Sands with Fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below.)				
			SC	Clayey sands, sand-clay mixtures.	Plastic fines (for identification procedures see CL below.)				
					Identification Procedures on Fractions Smaller than No. 40 Sieve Size				
					Dry Strenght (Crushing characteristics)	Dilatancy (Reaction to shaking	Toughness (Consistency near PL)		
Fine - grained Soils More than half of material is smaller than No. 200 sieve size.	Silts and Clays Liquid limit is less than 50		ML	Inorganic silts and very fine sands rock flour, silty or clayey fine sands or clayey silts with slight plasticity.	None to slight	Quick to slow	None	For undisturbed soils add information on structure stratification, consistency in undisturbed and remolded states, moisture and drainage conditions. Give typical name; indicate degree and character of plasticity; amount and maximum size of coarse grains; color in wet conditions; odor, if any; local or geologic name and other pertinent descriptive information; and symbol in parentheses. Example: Clayey silt, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (ML).	Use grain - size curve in identifying the Fractions as given under field identification.
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	Medium to high	None to very slow	Medium		
			OL	Organic silts and organic silts clays of low plasticity.	Slight to Medium	Slow	Slight		
	Silts and Clays Liquid limit is greater than 50		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	Slight to Medium	Slow to none	Slight to Medium		
			CH	Inorganic clays of high plasticity, fat clays.	High to very high	None	High		
			OH	Organic clays of medium to high plasticity, organic silts.	Medium to high	None to very slow	Slight to Medium		
Highly Organic Soils			Pt	Peat and other highly organic soils.	Readily identified by color, odor, spongy feel and frequently by fibrous texture.				

$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4

$C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3

Not meeting all graduation requirements for GW

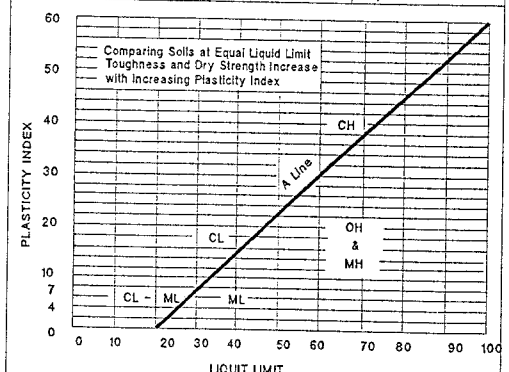
Atterberg limits below "A" line or PI less than 4	Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols.
Atterberg limits above "A" line with PI greater than 7	

$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6

$C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3

Not meeting all graduation requirements for SW

Atterberg limits below "A" line or PI less than 4	Limits plotting in hatched zone with PI between 4 and 7 are borderline cases requiring use of dual symbols.
Atterberg limits above "A" line with PI greater than 7	



PLASTICITY CHART

For laboratory classification of fine - grained soils

(1) Boundary classification: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well-graded gravel-sand mixture with clay binder. (2) All sieve sizes on this chart are U.S. standard.

FIELD IDENTIFICATION PROCEDURES FOR FINE - GRAINED SOILS OR FRACTIONS

These procedures are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (reaction to shaking)

After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky.

Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearence of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens, and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (crushing characteristics)

After removing particles larger than No. 40 sieve size, mold a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to try completely by oven, sun, or air-drying, and then test its strength by braking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic for clays of the CH group. A typical inorganic silt passes only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toughness (consistency near plastic limit)

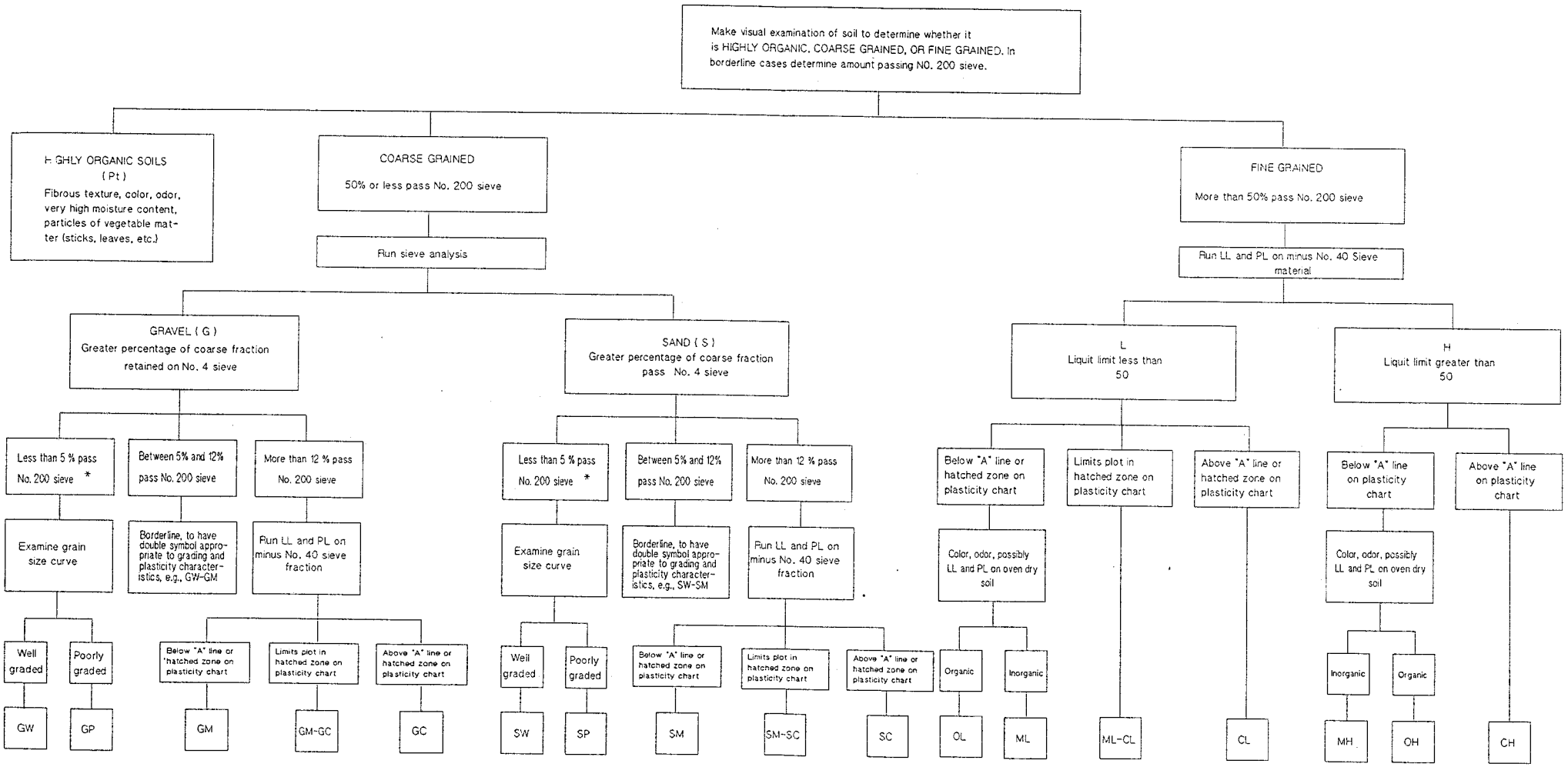
After particles larger than the No. 40 sieve size are removed, a specimen of soil about one-half inch in cube size is molded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eighth inch in diameter. The thread is then folded and rerolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

Identification of Soils Under Unified Soil Classification System



Note : Sieve sizes are U. S. Standard.

* If fines interfere with free draining properties use double symbol such as GW - GM, etc.

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VEHICLE TESTING
PUBLICATION

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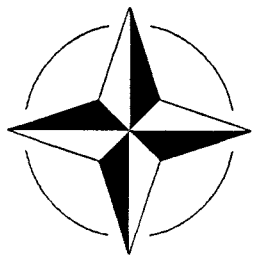

NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : PERFORMANCE

TEST TITLE : FORDING

REFERENCE : STANAG 4357
STANAG 4358
STANAG 2805

EQUIVALENT : WEU 4FT6 NO.: TM 03-110
ITOP NO.: 2-2-612 (1)

FOR COMPLIANCE WITH : -

ABSTRACT : This AVTP describes procedures for evaluating the fording ability of military vehicles as well as the effectiveness of fording kits.

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NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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FOR THE MILITARY AGENCY OF STANDARDIZATION

(Signature)

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RECORD OF CHANGES, AMENDMENTS AND RESERVATIONS *)

Identification of Change or Amendment and Reg.No.(if any) and date	Date Entered	NATO Effective Date	By whom entered Signature, Rank, Grade or Rate, Name of Command

*) See Reservations Overleaf

AVTP : 03-110
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Trial Series: PERFORMANCE

Test Title : FORDING

Paragraph

AVTP : 03-110
EDITION NO.: FINAL
DATE : SEP. 1991

1. SCOPE

This document describes procedures for evaluating the fording ability of military vehicles as well as the effectiveness of fording kits. Fording capability for tactical vehicles is critical to movement of military units across rivers, streams and other small bodies of water when bridges and bridging devices are not available.

Types of fording covered by this procedure can be found in the draft of STANAG 2805 (Edition 4), where "shallow fording", "deep fording" and "underwater fording" are defined as follows:

Fording. The capability of a ground vehicle to negotiate a water obstacle with its wheels or tracks in contact with the ground:

(1) Shallow fording: The capability of a combat or support ground vehicle equipped with built-in water-proofing, with its wheels or tracks in contact with the ground, to negotiate a water obstacle without the use of a special water-proofing kit.

(2) Deep fording: The capability of a combat or support ground vehicle equipped with built-in water-proofing and/or a special water-proofing kit to negotiate a water obstacle with its wheels or tracks in contact with the ground.

(3) Under-water fording: The capability of a combat or support ground vehicle equipped with built-in water-proofing and/or a special water-proofing kit, to negotiate a water obstacle with its wheels or tracks in contact with the ground, completely immersed.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

a. Fording basin.

b. Normal safety precautions including safety devices, as applicable.

c. Recovery equipment.

d. Scuba diving equipment, if necessary.

2.2 Instrumentation

DEVICES FOR MEASUREMENT MEASUREMENT OF:	PERMISSIBLE ERROR OF MEASUREMENT*
a. Water depth	2 %
b. Depth of water leakage	10 %
c. Engine speed	2 %
d. Vehicle speed	1 %
e. Time	1 %
f. Temperature	1 °C
g. Toxic fumes	5 %
h. Water contamination	5 %

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement of 20.

3. REQUIRED TEST CONDITIONS

3.1 Test Vehicle

Ensure that:

a. The vehicle is prepared and equipped to the standard anticipated for operations or as specified by the test plan.

b. Reference fuels and lubricants as specified by relevant NATO authority (after ratification) have been used. Until NATO agreement is ratified, developer specified POL will be used.

c. Maintenance and service operations have been performed to ensure that the vehicle is operating within manufacturer's specifications. Give particular attention to bilge pumps, intake and exhaust system, compartment seals and all openings.

d. Samples of lubricants from components such as engine, transmission and axles have been taken prior to fording operations.

e. The vehicle is operating at normal operating temperatures and pressures.

3.2 Test Facilities

Fording basin shall be filled to required depths for shallow-water, deep-water, and underwater operations.

4. TEST PROCEDURE

4.1 Shallow water tests

4.1.1 Fording

a. Adjust water level to the maximum required.

b. With headlights on drive the vehicle slowly into the water, so as to cause minimum water disturbance.

c. Apply the brakes three times during immersion.

d. Check for major water leakage.

e. Remain in water for a period of at least 15 minutes or greater as specified in the test plan; if no major water leakage is noted during this time, stop engine twice for 10 minutes and determine restarting capability (unless restricted by design limitations).

f. Observe total amount of water leakage into the compartments, and measure depth of such leakage, if appropriate.

g. Drive the vehicle slowly out of the water.

h. If appropriate, operate vehicle and functionally check steer control and braking ability.

i. Take samples of lubricants for analysis and compare with those taken before fording and check for water contamination.

j. Check all components including lights and brake system for correct operation and water leakage.

4.1.2 Speeds

a. Drive the vehicle via the available ramps into the water at a slow speed. (STANAG 2805 requires 40% entry and 30% exit gradients).

b. Observe the critical openings (air intake) of the vehicle for entering surge water.

c. Attempt vehicle operation in the basin at increased speed up to the maximum obtainable safe speed. Care should be taken not to reach speeds that could force water into the air-intake system.

d. Drive the vehicle via the available ramps out of the water at a slow speed.

e. Increase the speeds for entering and exiting the water via the available ramps until the maximum safe speeds are determined.

4.2 Deep-water tests

a. Install the fording kit and make all required preoperational adjustments and checks.

b. Conduct tests as in paragraphs 4.1.1.a. through 4.1.1.h. if the fording kit has an underwater start capability; if it does not have such capability, maintain specified engine speed during fording operations.

4.3 Underwater tests

a. Install the fording kit and make all required adjustments and checks.

b. Follow all of the procedures and perform all of the checks used for shallow- and deep-water tests.

c. Conduct test based on vehicle specifications.

d. Take toxic fumes measurements in the crew compartment while the vehicle is under water.

e. Monitor coolant and/or lubricant temperatures during fording operations.

5. DATA REQUIRED

5.1 Shallow-water tests

a. Water depth.

b. Time in water.

c. Observations and depth of water leakage.

d. Observations of restarting capability.

e. Observations of steer control and braking.

f. Water contamination of lubricants.

g. Vehicle speed.

h. Gradients of ramps used.

i. Specifications of POL used, including production lot number, if known.

5.2 Deep-water tests

a. Personnel and time required to install and remove kit.

b. Adequacy of bilge pumps.

c. Engine speed.

d. All items in paragraphs 5.1.a. through 5.1.i.

5.3 Underwater tests

a. Toxic fumes concentrations.

b. All items in paragraphs 5.1.a. through 5.1.i.

6. PRESENTATION OF DATA

Present the required data in narrative, tabular, graphical, pictorial or other format as appropriate.

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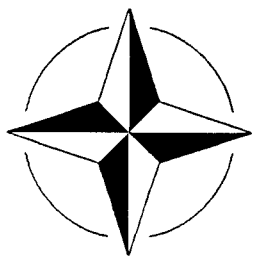

NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : PERFORMANCE

TEST TITLE : AMPHIBIOUS CAPABILITY

REFERENCE : STANAG 4357
STANAG 4358
STANAG 2805

EQUIVALENT : WEU 4FT6 NO.: TM 03-120
ITOP NO.: 2-2-501(1)

FOR COMPLIANCE WITH : -

ABSTRACT : This AVTP describes procedures to assess the performance of vehicles in water.

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NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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FOR THE MILITARY AGENCY OF STANDARDIZATION

(Signature)

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RECORD OF CHANGES, AMENDMENTS AND RESERVATIONS *)

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*) See Reservations Overleaf

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DATE : SEP. 1991

Trial Series: PERFORMANCE

Test Title : AMPHIBIOUS CAPABILITY

Paragraph

AVTP : 03-120
EDITION NO.: FINAL
DATE : JAN. 1994

1. SCOPE

This AVTP describes procedures to assess the performance in water of vehicles which have either built-in floating/swimming capability or kits to enable them to float or swim. This performance is critical to tactical vehicle crossing of deep-water obstacles.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

a. Water facilities; various conditions and sites, depending on item and test phase.

b. Camera

c. Safety patrol boat with a diving team.

d. Normal safety precautions including safety devices, as applicable: e.g.

- Marker buoys
- Sighting poles
- Recovery equipment

2.2 Instrumentation

DEVICES FOR MEASUREMENT OF:	PERMISSIBLE ERROR OF MEASUREMENT*
a. Vehicle speed	1 %
b. Engine and wheel speed	2 %
c. Force	2 %
d. Distance	2 %
e. Tyre/pad wear	0.5 mm
f. Tyre pressure	10 kPa

g. Time	1 %
h. Turning radius	10 %
i. Freeboard	10 %
j. List and trim	10 mrad
k. Water current	3 %
l. Water depth	3 %
m. Wind speed	5 %
n. Wind direction	50 mrad
o. Ramp angle	1 °
p. Air temperature	1 °C
q. Air pressure	1 %

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement of 20.

3. REQUIRED TEST CONDITIONS

3.1 Test vehicle

Ensure that:

a. The vehicle is prepared and equipped to the standard anticipated for operations or as specified by the test plan.

b. Maintenance and service operations have been performed to ensure that the vehicle is operating within manufacturer's specifications. Give particular attention to engine, transmission, bilge pump and water seals.

c. Reference fuels and lubricants as specified by relevant NATO authority (after ratification) have been used. Until NATO agreement is ratified developer-specified petroleum, oils and lubrications (POL) will be used.

d. The proper quantities of lubricants have been used.

e. Normal operating temperatures of fluids and components are reached before starting the test.

3.2 Test course

a. Water must be at least 4 m in depth, be of the required width and have negligible (≤ 0.5 m/s) current velocity.

b. Wind speed shall not be more than 3 m/s.

c. After determining the amphibious capability in calm water, investigate a range of currents across, with and against the direction of travel of the test vehicle (if possible).

3.3 Suggested Support Equipment

a. A safety patrol boat with qualified personnel and equipment.

b. Life jackets for all test personnel.

c. A communications system to ensure immediate response of emergency assistance.

d. A heavy-duty cable bridle attached to each end of the test vehicle and secured so that it will be available for recovery operations.

e. If testing is conducted in deep water, a marker buoy attached to the test vehicle to locate it in case it sinks.

f. An board breathing air supply for each eventual crew member.

4. TEST PROCEDURE

4.1 Preparation for testing

Prepare the vehicle for operation in water in accordance with prescribed procedures.
Drive the vehicle into calm water, just deep enough to float clear of bottom, to determine:

a. Adequacy of static floating attitude.

b. Tightness of body, door and hatch seals.

c. Proper functioning of bilge pumps.

d. Ability to operate and restart engine.

e. Reserve buoyancy (for this test additional load is put on the vehicle in order to lower the vehicle parallel to the water surface until zero freeboard has been reached), if desired.

4.2 Maximum speed through water

a. Operate the vehicle in deep water and depress the accelerator slowly up to maximum over a straight course.

b. Measure maximum sustainable vehicle speed in both directions of travel. This measure is to be taken between two points.

c. Make observations of the ability to maintain a straight course.

d. From a stabilized maximum speed forward condition, shift transmission into reverse and apply fully depressed accelerator pedal. Measure minimum time and distance required to stop forward motion. Repeat the test in the reverse to forward condition.

4.3 Manoeuvring

a. Operate the vehicle forward in deep water at maximum safe speed and maximum steer input, right and left, in a full circle.

b. Measure minimum circumference of circle described by vehicle; repeat a sufficient number of turns in each direction to ensure representative results.

c. Measure the time required, from initial steer input, to achieve 90° and 180° turns in each direction.

d. If applicable, repeat paragraphs 4.3.a and 4.3.b above, in pivot steer; also measure the time for a full 360° turn in each direction of steer.

4.4 Bollard Pull

a. Moor the vehicle to a bollard or other rigid structure on shore; include a force-measuring device in the mooring line. The distance of the vehicle from the mooring point should be sufficient to avoid turbulence effects.

b. In each applicable gear range, operate the engine at several speed increments, to maximum rpm.

c. Measure bollard pull at each engine speed in forward and reverse direction.

4.5 Dynamic Pull (optional)

Measure the dynamic pull of the vehicle at sufficient speed increments.

4.6 Entrance and exit ability (if possible)

Conduct entrance and exit operation of the vehicle on fixes and/or natural banks with varying angles and at different current speeds with and without on-board winches, if applicable.

5. DATA REQUIRED

5.1 Preparation for testing

a. Personnel required, to prepare the vehicle for water operation.

b. Time required, expressed in minutes, to prepare the vehicle for water operation.

c. Check equipment required, to prepare the vehicle for water operation.

d. Conditions of tyres or tracks and other ancillary equipment used.

e. Vehicle weight distribution.

f. Static freeboard (at each corner).

g. Static list and trim.

h. Leakage rate and location of leakage, if significant.

i. Additional load utilised to adjust freeboard, if required.

5.2 Maximum speed through water

a. Vehicle speed.

b Engine speed.

c. Speed of propulsion elements acting on the water.

d. Time and distance required to stop from maximum forward and reverse speed.

e. Gear ranges.

f. Freeboard (at each corner).

g. List and trim.

i. Water depth.

j. Current flow and direction.

k. Estimated wave height, if any.

l. Length of course.

m. Wind speed and direction.

n. Air temperature.

o. Air pressure.

p. Observations relative to control and minimum corridor width.

5.3 Manoeuvring

a. Minimum turning diameter.

b. Time, to complete the turn.

c. Engine speed.

d. Gear ranges.

e. Freeboard (at each corner and where at a minimum).

f. List and trim.

g. Water depth.

h. Current speed and direction.

i. Estimated wave height, if any.

j. Wind speed and direction.

k. Observations relative to control, stability and crew vision.

l. Speed of propulsion elements.

5.4 Bollard Pull

a. Bollard pull.

b. Engine speed.

c. Speed of propulsion elements.

d. Gear range.

e. Water depth.

f. Geometry of mooring points.

5.5 Dynamic Pull (optional)

a. Dynamic pull.

b. Vehicle speed.

c. Speed of propulsion elements.

d. Engine speed.

5.6 Entrance and exit ability

Report of observations on entrance and exit ability of the vehicle.

6. PRESENTATION OF DATA

Present the required data in narrative, tabular, graphical, pictorial or other format as appropriate.

Include graphs of:

a. Bollard pull versus engine speed.

b. Dynamic pull versus vehicle speed.

c. Vehicle speed versus speed of propulsion elements or/and engine speed.

d. Freeboard versus vehicle speed.

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VEHICLE TESTING
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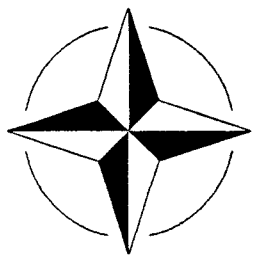

NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : PERFORMANCE

TEST TITLE : ENGINE COLD START

REFERENCE : STANAG 4357
STANAG 4358
STANAG 2895

EQUIVALENT : WEU 4FT6 NO.: TM 03-130
ITOP NO.: 2-2-650 (1)

FOR COMPLIANCE WITH : -

ABSTRACT : This AVTP describes procedures for testing the cold starting capability of military vehicle engines.

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EDITION NO.: FINAL
DATE : SEP. 1991

NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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FOR THE MILITARY AGENCY OF STANDARDIZATION

(Signature)

AVTP : 03-130
EDITION NO.: FINAL
DATE : SEP. 1991

RECORD OF CHANGES, AMENDMENTS AND RESERVATIONS *)

Identification of Change or Amendment and Reg.No.(if any) and date	Date Entered	NATO Effective Date	By whom entered Signature, Rank, Grade or Rate, Name of Command

*) See Reservations Overleaf

AVTP : 03-130
EDITION NO.: FINAL
DATE : SEP. 1991

Trial Series: PERFORMANCE

Test Title : ENGINE COLD START

Paragraph

AVTP : 03-130
EDITION NO.: FINAL
DATE : SEP. 1991

1. SCOPE

a. This AVTP describes procedures for testing the cold starting capability of military vehicles engines.

b. A successful start is defined as a start of a cold-soaked vehicle with a continuous total cranking period as defined in the test plan, followed by an engine idling period of at least 2 minutes.

c. Testing is always conducted with fully charged batteries; however, additional testing is sometimes required with lower-charged batteries to simulate field operational conditions.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

A temperature chamber for conditioning the vehicle to temperatures as required in paragraph 4.

2.2 Instrumentation

DEVICES FOR MEASUREMENT OF:	PERMISSIBLE ERROR OF MEASUREMENT*
a. Temperature	1°C
b. Specific gravity	0.5%
c. Time	1 s
d. Voltage	1 %
e. Current	3 %
f. Engine cranking speed	1 %
g. Pressure (as required)	5 %

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement of 20.

3. REQUIRED TEST CONDITIONS:

The following procedure should be carried out at ambient temperature.

Ensure that:

a. The vehicle is fully functional. Give particular attention to power train performance by using adequate procedures (e.g. 03-50, 03-60) and/or performance checks on test stands, if appropriate. Replace vital parts (filters, thermostat, battery heater plugs, spark plugs, injection, etc.) if required.

b. The vehicle is prepared for cold weather conditions as specified in the test plan (with or without preheating).

c. Reference fuels, lubricants and antifreeze as specified by relevant NATO authority (after ratification) have been used. Until NATO agreement is ratified, developer-specified petroleum, oil, lubricants and antifreeze will be used. Check fuel to be used for test according to specifications and record lab data.

d. The engine crankcase and vehicles fuel tank are filled to maximum. The quantities of other lubricants are as specified in the test plan.

e. Both fully charged and lower-charged (at 20°C) cold-soaked batteries are used during the cold-start attempts.

4. TEST PROCEDURES

4.1 Cold start without preheating

4.1.1 General

Determine the temperature at which the engine can be started without preheating, by repeating the procedure below at temperatures specified in the test plan. Obtain successful starts at the higher temperature before proceeding to the lower test temperature for each battery

charge. If a start attempt is unsuccessful, start the engine by slaving, warming, or other appropriate means to purge unburned fuel before continuing or repeating the test. If necessary change the filters. After cranking or starting, the vehicle must be cold soaked again as described in para. 4.1.2 before attempting the next start.

4.1.2 Cold soaking

Cold soaking are defined by the two following methods which may lead to different results.

First Method
Cold soak the vehicle at the higher test temperature for a minimum of 8 hours after all with thermocouples instrumented components have stabilized to within 2°C of the specified temperature. When applicable, use cool-down blowers to facilitate equipment cold soaking.

Second Method
Place the vehicle in the cooling chamber at ambient temperature. Bring the chamber temperature to 5°C. Adjust wind speed to 15 km/h, preferably towards the front of vehicle. Then adjust the temperature control system so that the test temperature is reached after 12 hours according to a linear temperature drop. Maintain the test temperature for 4 hours.

4.1.3 Engine cold start with 100% battery charge

(a) Attempt to start the vehicle using a 100% battery charge (procedure described in ANNEX A) and the appropriate instructions.

(b) Record data of Para. 5.

(c) If engine start was successful at higher temperature, repeat the test with the same battery charge at the lower temperature, starting with cold soaking at the lower temperature.

(d) If ambient air temperature in the chamber varies more than 5°C during a test, the test is repeated.

4.1.4 Engine cold start with lower battery charge

If engine start at 100% battery charge was successful repeat the test as described in para. 4.1.3 with lower battery charge. Discharge battery to specified charge as described in ANNEX A.

4.2 Cold start with preheating

4.2.1 General

Determine the temperature at which the vehicle can be started, with the aid of add-on engine preheat kits, as applicable, by repeating the procedure in paragraph 4.1 at temperatures as specified in the test plan.

4.2.2 Using the preheat kit and engine cold start

(a) Start the preheating procedure. When the temperatures specified in the test plan are reached, turn off the kit, and attempt to start the engine.

(b) If the engine fails to start, repeat the test, increasing the preheat time in increments until the engine starts or the specified maximum preheat time is accumulated.

(c) After the required time has been determined, follow the procedures in paragraphs 4.1.3 and 4.1.4.

5. DATA REQUIRED

a. Temperature of the following, as applicable:

(1) Air of the climatic chamber.

(2) Engine coolant (for liquid-cooled engines).

(3) Cylinder head (for air-cooled engines).

(4) Fuel at tank and filter outlet.

(5) Engine oil, sump.

(6) Battery electrolyte.

(7) Induction air.

(8) Transmission oil, sump.

(9) Hydraulic oil, reservoir.

(10) Battery box, ambient air.

(11) Starter housing.

b. Soak time

c. Preheat time (if preheat is required by starting procedure para. 4.2).

d. Battery voltage and specific gravity before test.

e. Engine cranking speed.

f. Battery voltage and current.

g. Starter cranking voltage and current.

h. Fluid pressure as required (fuel, oil).

i. Kit preheat time (para. 4.2.2).

j. Number of starting attempts.

k. Success or failure of each start attempt.

l. Description and method of obtaining battery charge condition.

m. Laboratory data of POL used (see ANNEX B and C).

n. Description of engine and transmission.

o. Starter operating time.

6. PRESENTATION OF DATA

Present the required data in narrative, tabular, graphical, pictorial or other format as appropriate.

Include:

Graphical presentations of data versus time, where appropriate.

AVTP : 03-130
EDITION NO.: FINAL
DATE : SEP. 1991

ANNEX A

STEPS FOR OBTAINING A REQUIRED STATE OF VENTED LEAD-ACID BATTERY CHARGE

The state of battery charge is referenced to the actual capacity of the charged battery. A required state of charge is obtained using the following steps:

FIRST EXAMPLE

1. Determination of the effective Capacity.

a. Discharge test battery to 6 V with 625-ampere current to determine whether battery satisfactorily returns to original voltage.

b. Charge the test battery at ambient temperature between 15 and 25°C with constant charging current $I_L = 0.5\ I_5$ until the battery voltage has reached 14.4 V across the battery poles.
Example: For a battery with a rated capacity of 125 Ah, the charging current $I_L = 0.5\ I_5 = 0.5 \times 125/5 = 12.5$ A
Continue charging with the same current I_L for 3 additional hours.

c. Discharge with constant-rated discharging current I_5 until the final discharge voltage of 9 V is obtained. The effective capacity of the battery results from multiplying I_5 by the time required to discharge the battery down to the final discharge voltage of 9 V.

2. Obtaining the Required State of Battery Charge.

a. Recharge the test battery in accordance with para. 1b.

b. Discharge with constant-rated discharging current I_5 until the required state of charge is reached.
Example: The effective capacity determined in accordance with para. 1 should be 120 Ah.
Required state of test battery charge: 50 %.
Therefore, 60 Ah must be taken from the fully charged test battery. By application of a discharging current of $I_5 = 25$ A the battery is discharged for 60/25 = 2.4 h.

NOTE: Test batteries should be used within two days after obtaining the required state of charge. If this not practical, test batteries should be fully charged in accordance with paragraph 1b, stored, and then should be discharged in accordance with para. 2 immediately prior to use.

SECOND EXAMPLE

1. Determination of the Effective Capacity.

a. Discharge battery to 6 V with 625-ampere current to determine whether battery satisfactorily returns to original voltage.

b. Charge the test battery at ambient temperature between 15 and 25°C with constant charging current $I_L = I_{20}$.
Example: For a battery with a rated capacity of 125 Ah, the charging current $I_L = I_{20} = 6.25$ A. Stop charging when the increase in voltage over the previous 2 hours is not greater than 2%.

c. Discharge with constant-rated discharging current I_{20} until the final discharge voltage of 10.5 V is obtained. The effective capacity of the test battery results from multiplying I_{20} by the time required to discharge the battery down to the final discharge voltage of 10.5 V.

2. Obtaining the Required State of Battery Charge.

a. Recharge the test battery in accordance with para. 1b.

b. Discharge with constant-rated discharging current I_{20} until the required state of charge is reached.
Example: The effective capacity determined in accordance with para. 1 should be 120 Ah.
Required state of test battery charge: 75 %.
Therefore, 30 Ah must be taken from the fully charged test battery. By application of a discharging current of $I_{20} = 6.25$ A the battery is discharged for 30/6.25 = 4.8 h

NOTE: Test batteries should be used within two days after obtaining the required state of charge. If this is not practical, test batteries should be fully charged in accordance with paragraph 1b, stored, and then should be discharged in accordance with para.2 immediately prior to use.

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ANNEX B

TABLE OF FUEL CHARACTERISTICS

Density at 15°C	g/cm^3
Sediment content	% of volume
Sulfur content	% of weight
Cetane number	-
Water content	ppm
Viscosity at 20°C and 40°C	mm^2/s
Distillation	
Start point	°C
10% of volume	°C
50% of volume	°C
90% of volume	°C
End point	°C
Cloud point	°C
Pour point	°C
Limit of filterability	°C

AVTP : 03-130
EDITION NO.: FINAL
DATE : SEP. 1991

ANNEX C

TABLE OF OIL CHARACTERISTICS

Density at 15°C	g/cm^3
Water content	ppm
Fuel content	% of volume
Viscosity at 100, 50 and 40°C	mm^2/s
Flashpoint	°C
Pourpoint	°C

ALLIED
VEHICLE TESTING
PUBLICATION

AVTP : 03-140
EDITION NO.: FINAL
DATE : SEP. 1991

NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : PERFORMANCE

TEST TITLE : LATERAL GUIDANCE FORCE

REFERENCE : STANAG 4357
STANAG 4358

EQUIVALENT : ITOP NO.: 2-2-829 (1)

FOR COMPLIANCE WITH : -

ABSTRACT : This AVTP describes the procedure for the determination of lateral guidance force. The lateral guidance force and the drawbar pull force are decisive factors for determining manoeuvrability of military vehicles.

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EDITION NO.: FINAL
DATE : SEP. 1991

NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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FOR THE MILITARY AGENCY OF STANDARDIZATION

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*) See Reservations Overleaf

AVTP : 03-140
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Trial Series: PERFORMANCE

Test Title : LATERAL GUIDANCE FORCE

Paragraph

AVTP : 03-140
EDITION NO.: FINAL
DATE : SEP. 1991

1. SCOPE

This document describes the procedure for the determination of lateral guidance force. Both the lateral guidance force and the drawbar pull force are decisive factors for determining the manoeuvrability of military vehicles. While the level of drawbar pull force is important for manoeuvrability in the direction of travel, lateral guidance force is of major importance during lateral operations, e.g., the ability of the vehicle to perform slalom-type manoeuvres. This ability of the vehicle is of tactical importance for those combat situations where evasive manoeuvres provide a significant advantage.

Furthermore, determination of the lateral guidance force provides additional information for evaluation of different track/tyre designs, track ground-contact characteristics and the ability of the vehicle to operate satisfactorily on side slopes.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

a. Mobile field dynamometer

b. Level test course

(1) Paved

(2) Sand

(3) Mixed soils

c. Fixed anchoring position

2.2 Instrumentation

DEVICES FOR MEASUREMENT OF:	PERMISSIBLE ERROR OF MEASUREMENT*
a. Force	2 %
b. Vehicle speed	1 %
c. Sprocket/Wheel speed	2 %
d. Tyre/Pad wear	0.5 mm
e. Tyre pressure	10 kPa
f. Angle	20 mrad
g. Cone index	10 %
h. Soil moisture content	2 % of full scale
i. Soil density	5 %
j. Soil depth (to hardpan)	2 cm
k. Vehicle sinkage	2 cm

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement of 20.

3. REQUIRED TEST CONDITIONS

3.1 Test Vehicle

Ensure that:

a. The vehicle is prepared and equipped to the standard anticipated for operations or as specified by the test plan.

b. Maintenance and service operations have been performed to ensure that the vehicle is operating within manufacture's specifications. Give particular attention to engine, transmission and running gear.

c. Reference fuels and lubricants as specified by relevant NATO authority (after ratification) have been used. Until NATO agreement is ratified, developer specified petroleum, oil, lubricants (POL) will be used.

d. The proper quantities of lubricants have been used.

e. Normal operating temperatures of fluids and components are reached before starting the test.

f. Nominal value of stall engine speed*) is checked, if applicable.

g. The vehicle tracks/tyres are in good condition and properly adjusted and maintained during test.

*)Stall engine speed is the stabilized engine speed, when engine is connected to a hydraulic torque converter with locked turbine, and when the accelerator pedal is fully depressed.

3.2 Test Course

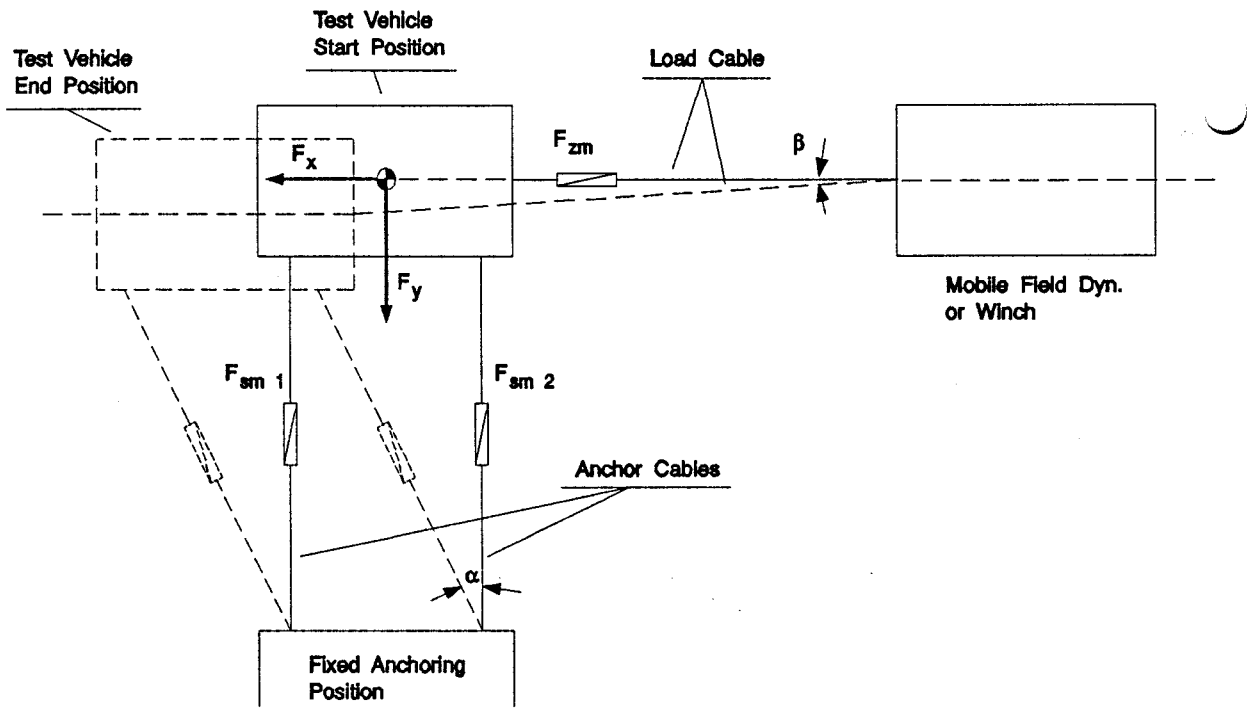
a. Paved level test course: Conditions must be clear and dry throughout the test.

b. Soft-soil test courses: Soil must be deep tilled to a depth of approximately 60 cm.

4. TEST PROCEDURE

4.1 Test Setup

The fix point for the anchor cables should be the same height (above ground) as the fix point of the load cable.



F_x = Force in x-direction
F_y = Force in y-direction
$F_{sm\ 1/2}$ = Forces in the anchor cables
F_{zm} = Force in the load cable
β = Angle between x-axis and the load cable
α = Angle between y-axis and the anchor cables

Force in x-direction: $F_x = F_{zm} \cdot \cos\beta + (F_{sm\,1} + F_{sm\,2}) \cdot \sin\alpha$
(drawbar pull)

Force in y-direction: $F_y = (F_{sm\,1} + F_{sm\,2}) \cdot \cos\alpha - F_{zm} \cdot \sin\beta$
(lateral guidance force)

4.2 Conduct of Test

a. Secure the test vehicle at one side by two parallel cables, approximately 30 m in length, anchored to fixed positions. The two cables must be taut, so that they do not touch the ground.

b. Starting without dynamometer load ($F_{zm} = 0$) and cable angles $\alpha \approx 0°$, drive test vehicle ahead at minimal speed (approximately 2 km/h), until the cable angles α have reached approximately 15°.
Measure forces F_{sm1}, F_{sm2} and angle α.

c. Attach mobile field dynamometer to test vehicle towing pintle with a cable approximately 30 m in length.
Repeat the test in paragraph 4.2.b a minimum of five times at approximately equal drawbar load increments (F_{zm}), until 100 % track/wheel slippage occurs, starting with $\alpha \approx 0°$ and $\beta \approx 0°$.
Measure forces F_{sm1}, F_{sm2} and angles α and β.

5. DATA REQUIRED

a. Vehicle speed

b. Force in the two anchor cables

c. Force in the load cable

d. Angle at the cables

e. Sprocket/Wheel speed

f. Gear range

g. Vehicle sinkage

h. Soil conditions

(1) Moisture content

(2) Cone-index readings

(3) Hardpan depth (CI 150 or greater)

(4) Density (fine-grained soils only, as required)

(5) Soil type -Unified Soil Classification- (fine-grained soils only)

6. PRESENTATION OF DATA

Present the required data in narrative, tabular, graphical, pictorial or other format as appropriate.

Include:

a. Lateral guidance force vs. drawbar force

b. Lateral guidance force vs. slippage

ALLIED
VEHICLE TESTING
PUBLICATION

AVTP : 03-150
EDITION NO.: FINAL
DATE : SEP. 1991

NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : PERFORMANCE

TEST TITLE : NOISE EMISSION

REFERENCE : STANAG 4357
STANAG 4358
ISO 362
ISO 5130

EQUIVALENT : WEU 4FT6 NO.: TM 03-150

FOR COMPLIANCE WITH : -

ABSTRACT : This AVTP describes the procedures for conducting steady-state noise emission tests of vehicles.

AVTP : 03-150
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DATE : SEP. 1991

NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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FOR THE MILITARY AGENCY OF STANDARDIZATION

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AVTP : 03-150
EDITION NO.: FINAL
DATE : SEP. 1991

Trial Series: PERFORMANCE

Test Title : NOISE EMISSION

AVTP : 03-150
EDITION NO.: FINAL
DATE : SEP. 1991

1. SCOPE

This document describes the procedures for conducting noise emission tests of vehicles. It is necessary to measure the noise emanating from military vehicles in order to compare with traffic regulations. For military requirements see AVTP 05-60.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

a. Level hard surface of 50 m radius.

b. No sound reflecting or deflecting obstructions within a radius of 50 m or as otherwise defined.

c. Paved level and straight course.
(See Annex A).

2.2 Instrumentation

DEVICES FOR MEASUREMENT OF:	PERMISSIBLE ERROR OF MEASUREMENT*
a. Noise level (measured in dB(A))	1.5 dB
b. Vehicle speed	2 %
c. Engine speed	2 %
d. Distance	2 %
e. Tyre or track pad wear	0.5 mm
f. Tyre pressure	10 kPa
g. Wind direction	50 mrad
h. Wind speed	5 %

i. Air temperature	1 °C
j. Air pressure	1 %
k. Air humidity	3 % of full scale

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement of 20.

3. REQUIRED TEST CONDITIONS

3.1 Test Vehicle

Ensure that:

a. The vehicle is prepared and equipped to the standard anticipated for operations or as specified by the test plan.

b. Maintenance and service operations have been performed to ensure that the vehicle is operating within manufacturer's specifications. Give particular attention to engine, transmission and running gear.

c. Reference fuels and lubricants as specified by relevant NATO authority (after ratification) have been used. Until NATO agreement is ratified developer-specified petroleum, oils, and lubricants (POL) will be used.

d. Normal operating temperatures of fluids and components are reached before starting each test.

e. Variable power absorbers (fans, etc.) are engaged in a repeatable configuration.

3.2 Test Courses

a. The test courses should be dry throughout the test.

b. The wind velocity should be less than 3 m/s, or otherwise specified.

c. The ambient noise level must be 10 dB(A) below the noise level produced by the vehicle during any tests.

d. The sound meter microphone must be 1.20 m above ground level.

4. TEST PROCEDURE

Prior to each test the ambient noise level is to be measured. The vehicle is to be measured unladen and laden, with and without trailer, as appropriate.

4.1 Stationary Test

a. With engine running from idle increase engine speed to give 50 %, 75 % and 100 % of the maximum rpm. The noise level is to be measured for each engine rpm from a distance of 7.5 m to the outer perimeter of the test vehicle.

b. Measure a 85 dB(A) contour around the vehicle with the engine at idle and 2/3 rated maximum rpm, if required.

4.2 Acceleration Test

a. The vehicle is to be positioned before A-A aligned centrally over the guide line C-C (See Annex A).

b. The vehicle shall approach the line A-A with the path of its centre line following as closely as possible the line CC as specified in Annex A at a speed of 50 km/h with an engine speed as near as possible to 3/4 of the maximum engine speed. When the front of the vehicle reaches the line A-A accelerate the vehicle at full throttle until the rear of the vehicle reaches line B-B; the throttle shall then be released.

c. Tests are alternated with runs made in the opposite direction (positioned before line B-B) to obtain noise levels on both sides of the vehicle.

d. Perform tests as otherwise specified, if required.

4.3 Constant Speed Test

With vehicle aligned centrally over the guide line C-C, approach A-A and in the opposite direction B-B at 75 % of the rated maximum engine speed. The speed and the selected gear should be maintained constant during the passage of the test vehicle between the limits of the noise recording section.

4.4 Engine Braking Test (optional)

The vehicle is to be driven at approximately 50 km/h towards crossing point MM-CC (see Annex A) aligned centrally over the guide line C-C. The engine brake is to be actuated as quickly as possible from a distance of 5 m, before the line M-M. This is to be repeated for distances of 10 m and 15 m before line M-M. The maximum measured noise level is recorded.

4.5 Replication

Each test should be repeated three times and the average of the two highest readings which are within 2 dB of each other are reported.

4.6 Other test procedures, as required

5. DATA REQUIRED

a. Vehicle identification

b. Noise level (highest value) (dB(A))

c. Vehicle speed)
) at A-A and B-B
d. Engine speed)

e. Background noise level (dB(A)) at each measuring point

f. Description of noise meter and meter settings for each test

g. Tyre or track pad wear

h. Tyre pressure

i. Wind speed

j. Wind direction

k. Air temperature

l. Air pressure

m. Relative humidity

n. Description of ground cover (especially snow)

o. Description of cloud cover

p. Test plan, if other required test procedures are used.

6. PRESENTATION OF DATA

Present the required data in narrative, tabular, graphical, pictorial or other format as appropriate.

AVTP : 03-150
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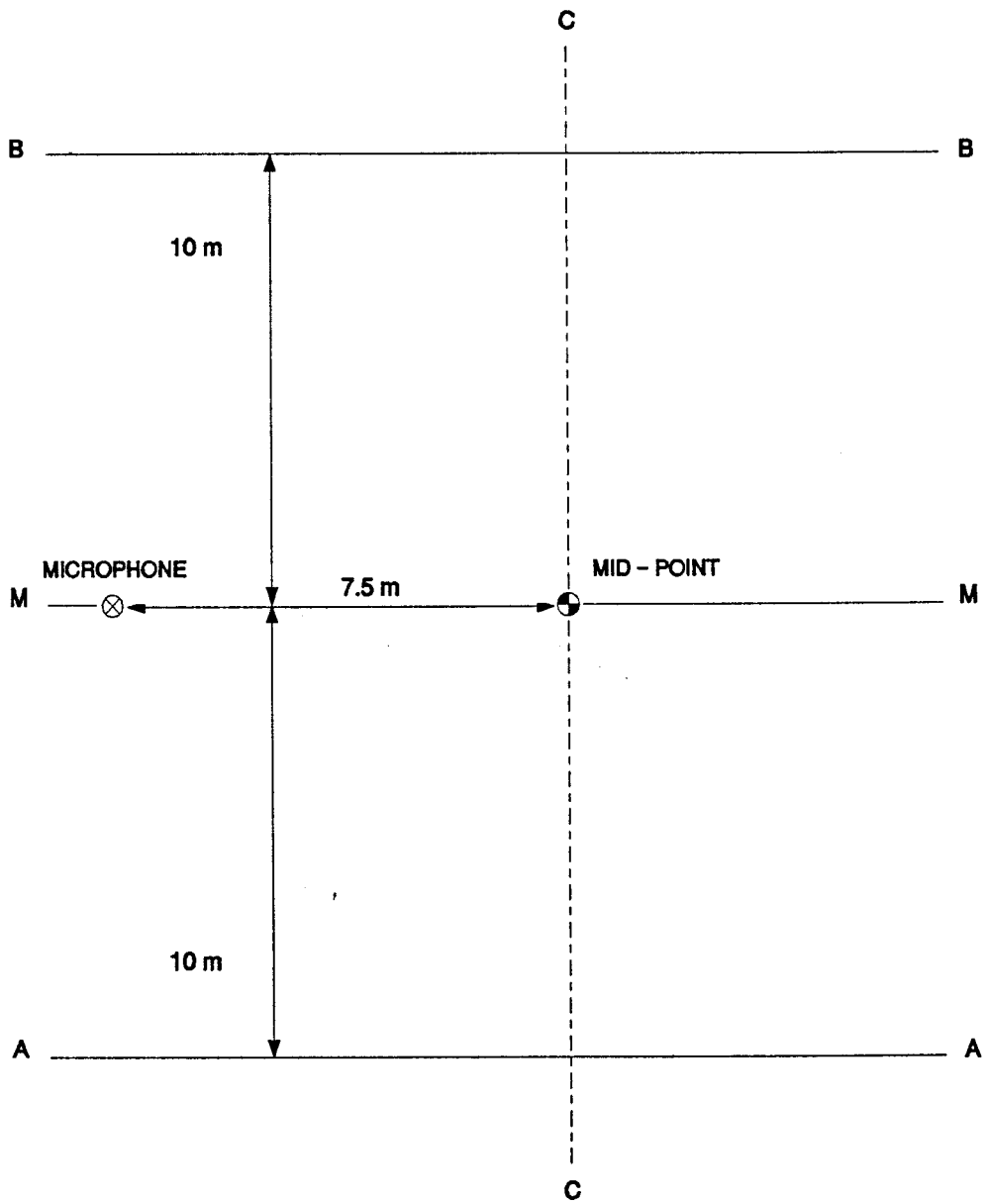
DATE : SEP. 1991

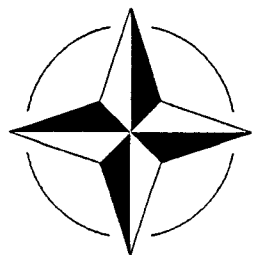
ANNEX A

Site Plan



ALLIED
VEHICLE TESTING
PUBLICATION

AVTP : 03-160 W
EDITION NO.: FINAL
DATE : SEP. 1991



NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : PERFORMANCE

TEST TITLE : DYNAMIC STABILITY

REFERENCE : STANAG 4357
STANAG 4358
ISO 4138
ISO TECHNICAL REPORT 3888

EQUIVALENT : WEU 4FT6 NO.: TM 03-160

FOR COMPLIANCE WITH : -

ABSTRACT : This AVTP describes how to determine the lateral dynamic stability of a vehicle during obstacle avoidance and manoeuvres when turning.

AVTP : 03-160 W
EDITION NO.: FINAL
DATE : SEP. 1991

NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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*) See Reservations Overleaf

AVTP : 03-160 W
EDITION NO.: FINAL
DATE : SEP. 1991

Trial Series: PERFORMANCE

Test Title : DYNAMIC STABILITY

Paragraph

AVTP : 03-160 W
EDITION NO.: FINAL
DATE : SEP. 1991

1. SCOPE

This document describes two methods of evaluating the dynamic stability of vehicles when taking avoiding action or cornering.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

a.Track:
- hard and level (uniform paved surface)
- good grip (coefficient ≥ 0.7)
- sufficiently large to carry out tests in safety
- slope of ≤ 2% in all directions.

b.Safety device with supporting wheels on either side of the vehicle, if required.

c.Cones or other means of marking lanes; their lay-out is given at ANNEX A.

d.Video equipment (if required).

2.2 Instrumentation

DEVICES FOR MEASUREMENT OF:	PERMISSIBLE ERROR OF MEASUREMENT*
a. Vehicle Speed	1 %
b. Time	1 %
c. Distance	2 %
d. Tyre Pressure	10 kPa
e. Tyre Wear	0.5 mm
f. Weather Data:	
(1) Ambient Temperature	1 °C
(2) Wind Direction	50 mrad
(3) Wind Speed	5 %
(4) Relative Humidity	3 % of full scale
and, if necessary:	
g. Turning Angle (Steering Wheel)	20 mrad
h. Turning Torque (Steering Wheel)	2 %

i. Roll Angle	5 mrad
j. Lateral Acceleration in the Horizontal Plane	0.15 m/s^2

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement of 20.

3. REQUIRED TEST CONDITIONS

3.1 Test vehicle

Ensure that:

a. The vehicle is prepared and equipped to the standard anticipated for operations or as specified by the test plan.

b. Maintenance and service operations have been performed to ensure that the vehicle is operating within manufacture's specifications. Give particular attention to the suspension, steering and tyres.
(The test may be performed with tyres in any state of wear, so long as, at the end of test, a minimum of 1.5 mm of tread depth remains over the whole circumference of the tyre. However, for a standard tyre condition, new tyres shall be used after being run-in for 150 to 200 km in the appropriate position on the test vehicle.)

c. Reference fuels and lubricants as specified by relevant NATO authority, (after ratification) have been used. Until NATO agreement is ratified, developer-specified POL will be used.

d. The proper quantities of lubricants have been used.

e. Normal operating temperatures of fluids and components are reached before testing begins.

3.2 Test course

- Clean and dry.
- Any other conditions laid down in the test plan.

3.3 Environment

- Wind speed ≤ 3 m/s.

4. TEST PROCEDURE

4.1 Steady state circular tests

a. The tyres shall be warmed up.

b. Drive the vehicle to the desired turning circle for a right turn (minimum diameter greater than 60 m).

c. Start the test at the lowest possible speed (≤ 5 km/h). Data shall be recorded with the steering wheel in a fixed position and the vehicle speed constant.

d. Drive the vehicle at the next speed at which data shall be taken. The increments of lateral acceleration should not be more then 0.5 m/s^2. At each speed level, the steering wheel position and speed shall be maintained as constant as possible while data are taken. Whatever radius is chosen (vehicle shall not deviate from the specified path by more than 0.3 m). Data shall be taken with the vehicle in steady state condition for at least 3 s for each trial condition. It is recommended that the highest gear ratio compatible with the conditions of the test should be used. The value of speed shall be increased and data shall be taken until it is no longer possible to maintain steady state conditions.

e. Repeat tests for a left turn.

f. Repeat the procedures above with all the circle diameters laid down in the test plan.

4.2 Double lane change tests

a. Cross the line 1-1a with the lowest vehicle speed laid down in test plan and drive in a straight line through the first section (See ANNEX A).

b. Keep the speed as steady as possible while crossing the entire test area.

c. Repeat the trial at the various speed increments laid down in the test plan until:
- the maximum speed laid down in the test plan is reached

or
- the limit of the vehicle's stability is attained

or
- it becomes impossible to cross the test area without knocking the cones down.

d. Record parameters and note the vehicle behaviour during the test.

e. Repeat the test in the opposite direction.

f. Repeat the test with two different drivers.

5. DATA REQUIRED

5.1 General parameters

a. Vehicle configuration:
- weight distribution
- mileage.

b. Note parameters laid down in the test Plan.

c. Tyre wear and pressure.

d. Meteorological conditions:
- temperature
- wind speed.
- wind direction

e. Vehicle characteristics:
- steering wheel turning angle.

5.2 Steady state circular tests

a. Test number.

b. Direction of turn.

c. Vehicle speed.

d. Gear ratio.

e. Radius of turning circle

f. Vehicle behaviour (with video film, if required)

and, if necessary:

g. Steering wheel turning angle.

h. Lateral acceleration in the horizontal plane.

i. Roll angle.

5.3 Double lane change tests

a. Characteristics of test course.

b. Test number.

c. Direction of course.

d. Speed during test.

e. Gear ratio.

f. Time taken to cross test area.

g. Vehicle behaviour (views given by drivers and independent observers or video film).

h. Extent to which the vehicle has kept to the driving lane (number and position of cones knocked down).

and, if necessary:

i. Steering wheel angle versus time.

j. Lateral acceleration, in the horizontal plane.

k. Roll angle.

l. Maximum speed during test without steering wheel correction.

6. PRESENTATION OF DATA

Present the required data in narrative, tabular, graphical, pictorial or other format as appropriate.

Include:

6.1 Steady state circular tests

Table giving for each course diameter:
- maximum speed
- vehicle behaviour.

6.2 Double lane change tests

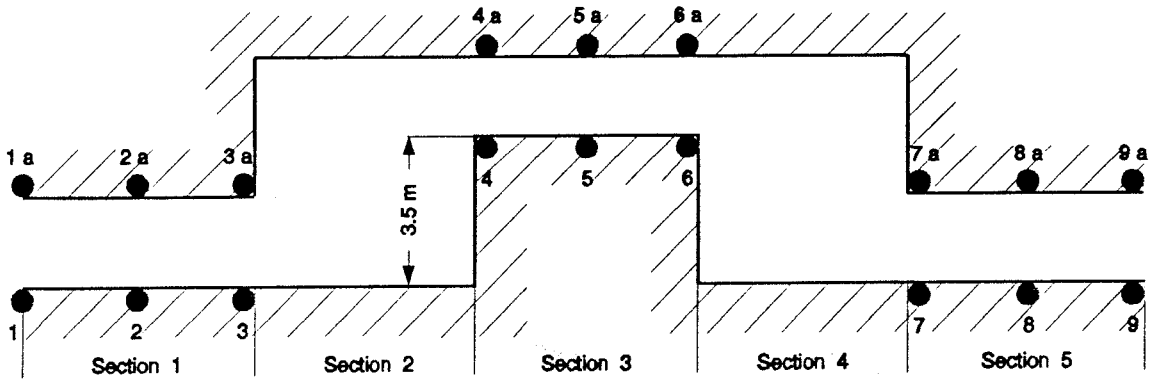
Drawing of test course showing actual dimensions.

Table giving for each speed:
- crossing time
- vehicle behaviour
- maximum speed during the test without steering wheel correction.

AVTP : 03-160 W
EDITION NO.: FINAL
DATE : SEP. 1991

ANNEX A

Figure 1: Lane-change track and designation of sections



Lane - change track dimensions

Section 1 : Length = 15 m
Width = 1.1 · vehicle width + 0.25 m

Section 2 : Length = Overall length of vehicle *) + 24 m

Section 3 : Length = 25 m
Width = 1.2 · vehicle width + 0.25 m

Section 4 : Length = Overall length of vehicle + 24 m

Section 5 : Length = 15 m
Width = 1.1 · vehicle width + 0.25 m

*) Overall length of vehicle, measured at 0.50 m from the ground.

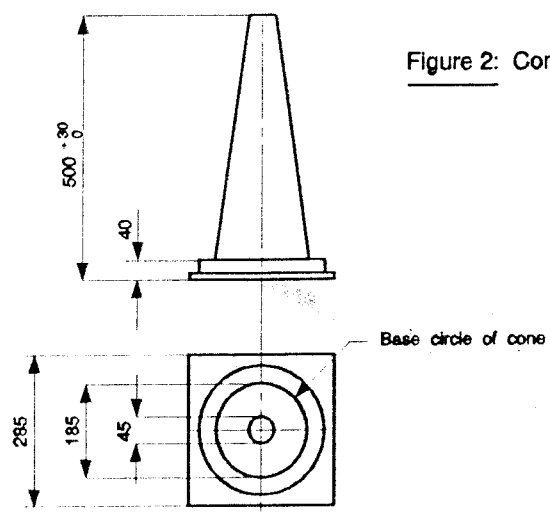


Figure 2: Cone used for lane-change track delineation

WEHRTECHNISCHE DIENSTSTELLE
FÜR KRAFTFAHRZEUGE UND PANZER

WTD 41

Wehrtechnische Dienststelle für Kraftfahrzeuge und Panzer · 54296 Trier

Verteiler

(Bitte bei Antwort angeben)
Geschäftszeichen: 3oo-72-25-12
Bearbeiter: LBDir Franken
Ruf - Nr: 41o

Trier
Grüneberg
.. .o9.1994

AT III 4, KG I 1

Standarderprobungsverfahren (SEV) für Fahrzeuge

hier: Erweiterung des SEV o3-16o W (Fahrstabilität) um die vom TÜV-Rheinland e.V. unter dem Vertrag E/K22H/Foo28/E6oo1, Dezember 1987, vorgelegten Verfahren

Verteilerschreiben WTD 41 - 3oo - 72-25-12 vom 21.o1.1992

Für die Untersuchung der Fahrstabilität von Radfahrzeugen setze ich für den nationalen Gebrauch zusätzlich folgende Verfahren in Kraft:

SEV	VERSUCH
o3-16o-o1	Geradeausbremsen auf gleichmäßig griffiger Fahrbahn
o3-16o-o2	Bremsen auf µ-split
o3-16o-o4	Geradeausfahrt über Einzelhindernis
o3-16o-o5	Stationäre Kreisfahrt
o3-16o-o6	Lastwechsel aus stationärer Kreisfahrt
o3-16o-o7	Bremsen aus stationärer Kreisfahrt
o3-16o-o8	Stationäre Kreisfahrt über Einzelhindernis
o3-16o-o9	Lenkrückstellverhalten aus stationärer Kreisfahrt
o3-16o-1o	Sprungartiger Lenkeinschlag
o3-16o-11	Sinusförmiger Lenkeinschlag

Öffentliches Fernsprechnetz
(06 51) 2 20 31 (Vermittlung)

Allgemeines Fernsprechwählnetz d. Bw
Kennzahl 47 22 - 8 (Vermittlung)
Durchwahl 47 22-

Telex
42 62 82 bw dd

Telefax
(06 51) 2 50 53 (Post)
Durchwahl 47 22-6 00 (Bw)

SEV VERSUCH
o3-16o-13 Pendelschwingverhalten von Anhängern mit 1 Achse oder 1 Doppelachse

Die Verfahren liegen beim BWB - KG I 1 und bei der WTD 41 vor.

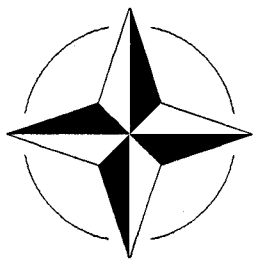
in Vertretung

Stabenow

Stabenow

ALLIED
VEHICLE TESTING
PUBLICATION

AVTP : 03-170
EDITION NO. : FINAL
DATE : OCT 1993



NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : PERFORMANCE

TEST TITLE : SUSPENSION PERFORMANCE

REFERENCE : STANAG 4357
STANAG 4358
ISO 8041
AVTP 10-30

EQUIVALENT : ITOP 2-2-714(1)

FOR COMPLIANCE WITH : -

ABSTRACT : This AVTP describes methods used to ascertain the performance of suspension systems in wheeled or tracked vehicles by using a variety of surfaces and representative obstacles.

AVTP : 03-170
EDITION NO.: FINAL
DATE : OCT 1993

NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

NATO LETTER OF PROMULGATION

1. NATO AVTP "SUSPENSION PERFORMANCE (03-170) is a NATO UNCLASSIFIED publication. Periodic accounting in not required.

2. AVTP: 03-170 is effective NATO-wide on receipt.

3. It is permissible to copy or to make extracts from this publication without the consent of the Authorising Agency.

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5. Recommended changes to or comments on this publication should be forwarded to the secretary AC/225 (Panel II), Land Armaments Section, NATO HQ, 1110 Brussels Belgium.

6. Any ratifying nation may issue supplemental testing information to amplify or clarify these procedures, but in no case will such information contravene the provisions of this AVTP. If a ratifying nation must deviate from a provision of this AVTP due to constraints such as available facilities, national regulations, instrumentation accuracies, etc., the test methods used will be described in the report. However, such deviation may cause nonacceptance of test data by other nations.

FOR THE MILITARY AGENCY OF STANDARDIZATION

(Signature)

AVTP : 03-170
EDITION NO.: FINAL
DATE : OCT 1993

RECORD OF CHANGES, AMENDMENTS AND RESERVATIONS *)

Identification of Change or Amendment and Reg.No.(if any) and date	Date Entered	NATO Effective Date	By whom entered Signature, Rank, Grade or Rate, Name of Command

*) See Reservations Overleaf

AVTP : 03-170
EDITION NO.: FINAL
DATE : OCT 1993

Trial Series: PERFORMANCE

Test Title : SUSPENSION

Paragraph

AVTP : 03-170
EDITION NO.: FINAL
DATE : OCT 1993

1. SCOPE

This document describes test methods to determine performance of wheeled and tracked vehicle suspension.
As it is not possible to reproduce or repeat tests easily on natural terrain, artificial courses are suggested to represent generally all types of difficult terrain which the running gear of vehicles might be likely to encounter.
The use of artificial courses will also allow comparison of performance between different vehicles.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

2.1.1 Sine Wave Tracks

Two sets of sinusoidal corrugations which enable the vehicle to achieve, in turn, resonance in pitching and resonance in bouncing/heaving at a reasonable speed. As a guide, this can be achieved by corrugations with the following characteristics:

- wavelength approximately 1.5 times vehicle wheelbase, and amplitude approximately ±0.1 m.

- wavelength which is an integer multiple (2 or greater) of the vehicle wheelbase, and amplitude approximately ±0.1 m.

2.1.2 Large Single Obstacles (See ANNEX A-1)

a. Ascending ramps with various gradients between 20% and 50%, and suffiently long to accommodate the overall wheelbase of the vehicle.

b. Descending steps higher than 0.2m.

2.1.3 Small Single Obstacles

Short obstacles of which the height (or depth) is less than or equal to the travel (compression stroke or expansion stroke) of the suspension with the addition of the compression (or expansion) of the tyre (e.g. 0.1m, 0.15m, 0.25m, 0.4m etc).

a. Trapezoidal obstacles (see ANNEX A-2).

b. Semicircular Obstacles (see ANNEX A-2).

c. Straight-sided ascending steps (see ANNEX A-3).

d. Other obstacles (e.g. low wall, tree trunks, holes etc).

2.1.4 Courses with low amplitude

Courses with constant (e.g. 0.3m, 0.45m, 0.6m, 1m, 1.8m) or periodically variable low wavelength.

a. Corrugated track

Flat track with profiles set at intervals, either semicircular or sinusoidal (single phase connected at bottom) with a total height of e.g. 0.05m, 0.07m, 0.075m.

b. Washboard track
Sinusoidal undulation with a constant amplitude (e.g. ± 0.025m, ± 0.075m).

c. Tracks the same as the preceding but with certain variations:

- profiles positioned obliquely to the axis of straight or curved tracks.

2.1.5 Random profile tracks with low amplitude

Tracks comprising small convex or concave obstacles distributed at random (e.g. height or depth 0.025m - 0.08m) are to be described by their amplitude distribution and by photographs.

a. Belgian block course.

b. Small pothole tracks.

c. Random tracks with slight roughness (e.g. effective roughness of 0.02m).

d. Setts. (see ANNEX A-4)

2.1.6 Random profile tracks with high amplitude

Test courses comprising concave or convex obstacles of the same type or consisting of various obstacles distributed at random.

a. Test course with random gaussian distribution (e.g. effective roughness of 0.04m, 0.06m, 0.08m etc).

b. Test course comprising randomly distributed semi-circular obstacles (e.g. APG test course of 0.12m, 0.17m, 0.25m, 0.3m radii) (staggered bump course).

c. Test course with randomly distributed obstacles 0.11m to 0.15m high. (e.g. APG gun stabilizer test course).

d. Test course with different types of randomly distributed obstacles (height 0.08m, 0.12m, ...0.25m, 0.3m). (e.g. APG profile IV test course).

e. Large pothole test course: potholes distributed at random (e.g. 0.15m to 0.3m deep).

2.2 Instrumentation

DEVICES FOR MEASUREMENT OF:	PERMISSIBLE ERROR OF MEASUREMENT*)
a. Speed of vehicle	0.5 km/h or 5% whichever is greater
b. Acceleration	2%
c. Angle of pitch and/or roll	20 mrad
d. Vertical suspension travel	2%

e. Pressure (if required)	5%
f. Temperature (if required)	1 °C
g. Tyre pressure	10 kPa
h. Tyre/track pad wear	0.5 mm

*)The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus the stated errors must not be exceeded in more than 1 measurement of 20.

3. REQUIRED TEST CONDITIONS

3.1 Test Vehicle

Ensure that:

a. the vehicle has been prepared and equipped to the standard anticipated for operations, or as specified by the Test Plan.

b. the vehicle is loaded as specified in the Test Plan.

c. maintenance has been carried out so that suspension elements are adjusted to conform to the manufacturer's specifications. Give particular attention to the state of the tyres (pressure, wear) and suspension (springs, dampers, limit stops).

d. normal operating temperatures of fluids and components are reached before testing begins.

3.2 Test Courses

Courses must be clean and dry.

4. TEST PROCEDURE

4.1 Pitch and Bounce Test

a. Drive the vehicle at constant speed on the course described in 2.1.1. Begin at the lowest possible speed; increase speed by regular increments (e.g. 2.5km/h) until the speed of resonance (pitching or bouncing) is reached. Adjust the speed to determine as closely as possible the speed of resonance. If the vehicle behaves well under resonance, continue to increase speed up to the limit specified by the Test Plan.

b. Measure pitch angle, vertical acceleration on different points, vehicle speed, wheel travel, pressure and temperatures of components as a function of time.

4.2 Test of Energy Absorbing Capacity under Heavy Shock

a. Drive the vehicle at constant speed on the approach course to the obstacles described in 2.1.2, beginning at approximately 10km/h; increase speed by regular increments (e.g. 2.5km/h) until the vertical acceleration measured at a point on the vehicle floor reaches a predetermined threshold indicating that the suspension has bottomed (e.g. 25m/s^2 peaks at the base of the driver's seat, acceleration weighted in frequency according to Standard ISO 8041, overall body vibration, z axis).

b. Measure pitch angle, (if required) vertical acceleration on different points, vehicle speed, wheel travel, pressure and temperatures of components as a function of time.

4.3 Attenuation Test (optional) (See also AVTP 10-30)

a. Drive the vehicle at constant speed on one or more of the courses described in 2.1.3, 2.1.4, 2.1.5 or 2.1.6. Begin at approximately 10km/h, then increase speeds (e.g. 4 increments of 5km/h up to 30km/h, then 10 increments of 10km/h) up to the maximum speed specified, or until the limiting conditions described in the Test Plan are reached (e.g. when the acceleration at the base of the driver's seat reaches a predetermined threshold).

b. Measure pitch and roll angle (if required), vertical acceleration on different points, vehicle speed, wheel travel (and vertical acceleration if required), pressures and temperatures of components as a function of time.

5. DATA REQUIRED

a. Speed of vehicle.

b. Acceleration parallel to the vertical axis of the vehicle at the same height as the driver's seat but measured on the hull of the vehicle.

c. Angles of pitch and/or roll.

d. Vertical displacement of first wheel, last wheel and one middle wheel (or, for tracked vehicles, first, last and one intermediate road wheel e.g. third from rear).

e. Characteristics of test courses used (profile, length, gradient, camber etc).

If necessary:

f. Triaxial acceleration at the centre of gravity and/or driver's seat.

g. Vertical or triaxial acceleration near the axle of the first wheel (or road wheel) measured on the hub carrier (suspension rocker or wishbone).

h. Pressures of shock absorbers and/or hydropneumatic springs.

i. Temperature of shock absorbers and/or hydropneumatic springs.

j. Pressure in tension devices of tracks.

k. Ambient temperature.

AVTP : 03-170
EDITION NO.: FINAL
DATE : OCT 1993

6. PRESENTATION OF DATA

Present the required data in narrative, tabular, graphical, pictorial or other format as appropriate.

Include as appropriate:

- histograms
- power spectral density
- effective values.

Include:

6.1 Pitch and Bounce Test

a. Maximum pitch angle of the vehicle versus speed.

b. Maximum wheel travel versus speed.

c. Maximum acceleration from each measured point versus speed (ISO filtered if required).

d. Time restitution (amplitude a=f (t)) from the measured value data (for a representative time window).

6.2 Test of Energy Absorbing Capacity

a. Maximum pitch angle of the vehicle versus speed (if required).

b. Maximum wheel travel versus speed.

c. Maximum acceleration from each measured point versus speed (ISO filtered if required).

d. Time restitution (amplitude a= f(t)) from the measured value data (for a representative time window).

6.3 Attenuation Test

a. Maximum pitch and roll angle of the vehicle versus speed (if required).

b. Maximum wheel travel versus speed.

c. Maximum wheel vertical acceleration versus speed (if required).

d. Maximum acceleration from each measured point versus speed (ISO filtered if required).

e. Amplitude distribution, power spectral density, and effective value, the wheel travel and the measured acceleration for random course test (if required).

f. Time restitution (amplitude a= f(t)) from the measured value data (for a representative time window).

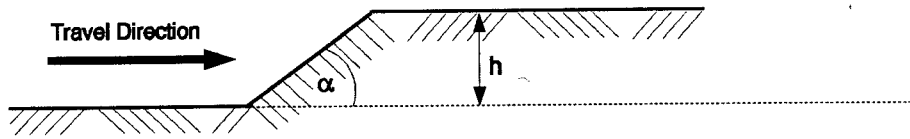
AVTP : 03-170
EDITION NO.: FINAL
DATE : OCT 1993

ANNEX A

OBSTACLES

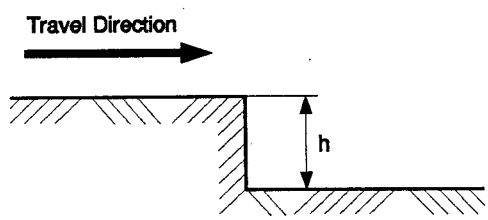
1. Ramps. (See paragraph 2.1.2)

a.



$tg\alpha \;\hat{=}\; 20\%$ to 50%
$h \geq 1.5m$

b. Descending Steps



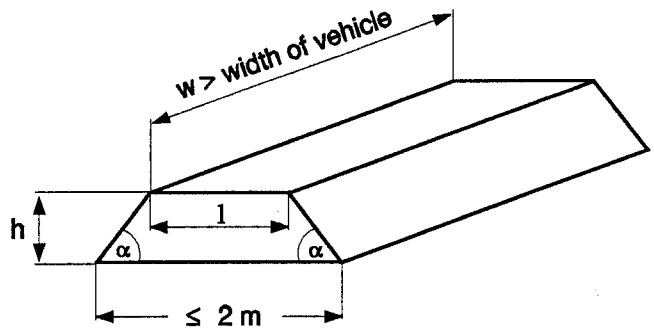
$h > 0.2m$.

AVTP : 03-170
EDITION NO.: FINAL
DATE : OCT 1993

ANNEX A

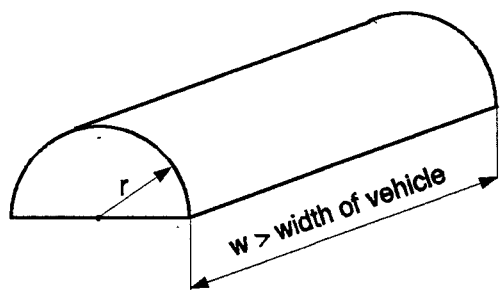
2. Small Single Obstacles (See paragraph 2.1.3)

a. Trapezoidal Obstacles (see paragraph 2.1.3 a.)



w > width of test vehicle
h = 0.1 to 0.4m
l = 0.2 to 0.5m
α = 30°

b. Semicircular Obstacles (see paragraph 2.1.3 b.)

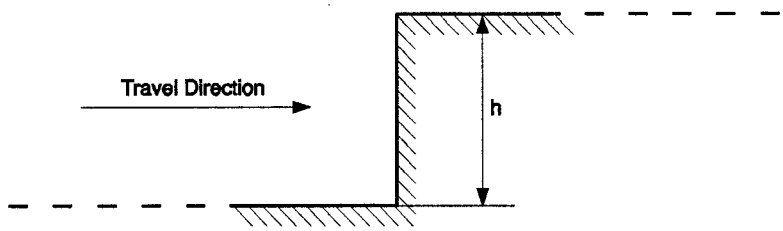


r = 0.1m, 0.15m, 0.25m, 0.4m

AVTP : 03-170
EDITION NO.: FINAL
DATE : OCT 1993

ANNEX A

b. Straight-Sided Steps (see paragraph 2.1.3.c.)

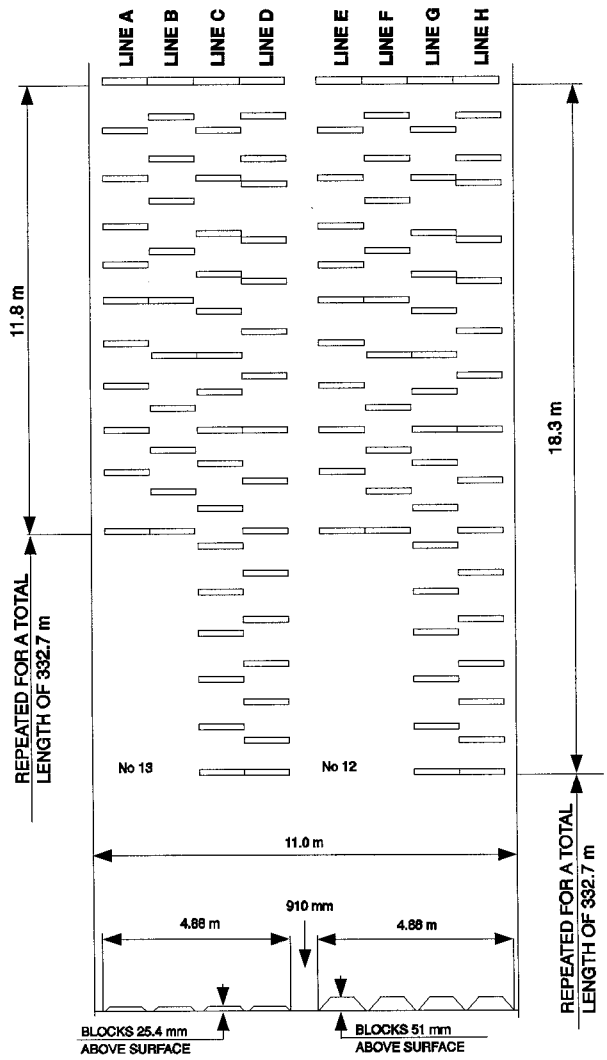


h = 0.1 to 0.3m

AVTP : 03-170
EDITION NO.: FINAL
DATE : MAY 1994

ANNEX A

EXAMPLE of SETTS (see paragraph 2.1.5.d.)



Blocks in Lines

A & B ARE PITCHED ALIKE BUT PHASED DIFFERENTLY
E & F ARE PITCHED & PHASED LIKE A & B RESPECTIVELY

C & D ARE PITCHED A LIKE BUT PHASED DIFFERENTLY
G & H ARE PITCHED & PHASED LIKE C & D RESPECTIVELY

PITCHING OF LINES A, B, E & F DIFFER FROM PITCHING OF LINES C, D, G & H

ALLIED
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PUBLICATION

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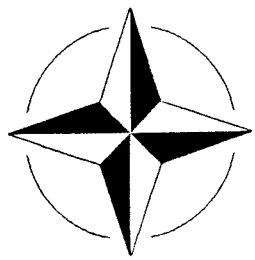
EDITION NO.: FINAL
DATE : SEP. 1991



NATO INTERNATIONAL STAFF-DEFENCE SUPPORT DIVISION

TRIAL SERIES : PERFORMANCE

TEST TITLE : ENGINE IDLING

REFERENCE : STANAG 4357
STANAG 4358
AVTP 03-70

EQUIVALENT : -

FOR COMPLIANCE WITH : -

ABSTRACT : This AVTP describes the procedures for testing the idling capability of military vehicle engines.

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DATE : SEP. 1991

NORTH ATLANTIC TREATY ORGANISATION
MILITARY AGENCY FOR STANDARDIZATION (MAS)

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FOR THE MILITARY AGENCY OF STANDARDIZATION

(Signature)

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DATE : SEP. 1991

RECORD OF CHANGES, AMENDMENTS AND RESERVATIONS *)

Identification of Change or Amendment and Reg.No.(if any) and date	Date Entered	NATO Effective Date	By whom entered Signature, Rank, Grade or Rate, Name of Command

*) See Reservations Overleaf

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Trial Series: PERFORMANCE

Test Title : ENGINE IDLING

Paragraph

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1. SCOPE

During military use vehicles will often be used stationary. To provide power for the equipment (e.g. radio, heater) the engine has to run for long periods of time unless there is an auxiliary power unit. In this kind of use (low engine speed, low output) the engine can become fouled due to a non-optimal combustion process.

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities

No special facilities are required other then those specified in referenced AVTP 03-70.

2.2 Instrumentation

DEVICES FOR MEASUREMENT OF:	PERMISSIBLE ERROR OF MEASUREMENT*
a. Engine speed	5 %
b. Exhaust smoke	5 % of full scale
c. Volume	5 %
d. Others	as specified in AVTP 03-70

* The permissible error of measurement for instrumentation is the two-sigma value for a normal distribution; thus, the stated errors should not be exceeded in more than 1 measurement of 20.

AVTP : 03-180
EDITION NO.: FINAL
DATE : SEP. 1991

3. REQUIRED TEST CONDITIONS

3.1 Test vehicle

Ensure that:

a. The vehicle has been prepared and equipped to the standard anticipated for operations or as specified by the test plan.

b. Maintenance and service operations have been performed to ensure the vehicle is operating within specifications. Give particular attention to the engine.

c. Reference fuels and lubricants as specified by relevant NATO authority (after ratification) have been used. Until NATO agreement is ratified, developer-specified POL will be used.

d. There are no leaks in the engine exhaust system.

e. The engine lubricating oil is at its maximum correct level.

f. The engine idling speed (and the fast idling speed, if applicable) has been adjusted in conformance with the manufacturers specifications.

g. Normal operating temperatures of fluids and components are reached before testing begins.

3.2 Environment

- desirable ambient temperature : $5\ ^{\circ}C \leq \theta \leq 35\ ^{\circ}C$
- desirable atmospheric pressure: ≥ 91 kPa
- relative humidity : ≤ 95 %

4. TEST PROCEDURE

4.1 Initial engine power measurement

To establish a baseline figure for engine power, the power of the engine is to be measured by the use of one of the methods detailed in AVTP 03-70.
Measure the exhaust smoke density in a full load condition for at least 4 engine speeds between 20 % above idling speed and the speed corresponding with max. torque.
Measurement of the blow-by volume is recommended.

4.2 Engine idling period

4.2.1 The engine must be allowed to run continuously for a period of 16 hours at its idling speed, or its fast idling speed, as specified in the test plan.
This must be done in a no load condition, that is no power must be taken from the engine other than that which is essential to support the running of the engine.
During the test the engine exhaust system must be checked visually for external leakages.

4.2.2 Check engine oil level and restore to the original level, making a record of the quantity of oil that has to be added or removed (if applicable).

4.3 Engine recovery procedure

Run the engine, in turn, at the following three conditions:

a. 5 min. at approx. 50 % of max. power (engine speed approximating to that of max. torque);

b. 5 min. at approx. 75 % of max. power (for example at a speed halfway between max. torque and max. power);

c. 30 min. at full power.

4.4 Final engine power measurement

4.4.1 Repeat the procedure of 4.1.

4.4.2 Check engine oil level and restore to the original level, making a record of the quantity of oil that has to be added or removed (if applicable).

4.4.3 If the above test has shown a significant power loss, perform the procedure of 4.3 and 4.4.1 again. If the full power of the engine cannot be recovered, perform diagnostic activities and remedial action as appropriate.

5. DATA REQUIRED

5.1 General parameters

- vehicle identification:
  . mileage
- note parameters to be checked as laid down in the test plan.
- environment conditions:
  . temperature
  . atmospheric pressure
  . relative humidity.
- description of engine power measurement.

5.2 Specific parameters

- results of power measurements before and after.
- exhaust smoke density before and after.
- blow-by volume before and after (if applicable).
- engine idling speed.
- quantity of oil added or removed after the idling period and after the final power measurement.
- results of inspections.
- unexpected occurrences (e.g. loss of oil pressure, coolant overheating, engine stoppage).

6. PRESENTATION OF DATA

Present the data in narrative, tabular, graphical, pictorial or other format as appropriate.

Include:

a. Statement of the power lost as a result of the idling period.

b. Photographs taken during the inspection.